SCIENCE

FRIDAY, NOVEMBER 4, 1910

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MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

SCIENCE AND PUBLIC SERVICE[1]

THE educational ideals of a people reflect in no small degree the social, political and industrial conditions of that people and of the nation of which they form a part. This is but natural. Those ideals of education that have prevailed in the past have stood in close relation to the general progress and development of civilization, and such ideals have always been, and must always continue to be, in conformity with those vital forces that dominate a nation's life and activity, as expressed in its art, its religion, its social and industrial conditions, and its form of government.

No more striking illustrations of this can be had than in the histories of Greece and Rome. The educational ideals of Greece found their source and inspiration in that emotional nature which worships the beautiful in both thought and action, and which finds its highest form of expression in literature, art and philosophy—the very essence of Grecian culture. The Roman ideals, on the other hand, were characterized by that rugged element of human strength which emphasizes the practical and reverences the useful. It trained men to frame laws, lead armies, construct aqueducts and public highways, and made possible that military success and judicial power which have not only commanded the admiration of all times, but have contributed to the general advance of civilization by becoming the bearer of eastern culture to the very confines of Europe. Again, when in the middle ages the church

[1] An address before the summer session of the University of Illinois Biological Station, July 22, 1910.

dominated both state and social institutions, quite different educational forces came into prominence.

As we now see, all of these educational motives were narrow and incomplete, and failed in the highest purposes of an education in that they each afforded an opportunity to develop strongly the ability of the individual in but a single direction. It was not until they became united, enriched and ennobled by that independence of thought and that Christian democracy which were the outgrowth of the protestant reformation that we find the dawn of that higher type of educational thought and activity which characterizes our modern institutions of learning.

Whatever may be our estimate of this or that system of education, or of this or that branch of study, we shall all agree that that education is best which best trains the individual to meet the demands of organized society as it exists and enables him to contribute most to the general welfare and advancement of the community and of the nation of which he is a member. Such a standard may and certainly does vary with the community and with the nation. Moreover, the educational ideals of any progressive people are bound to change with the development of national resources and national character and with the general progress of civilization. The instruction now offered by the great universities of Europe is quite different from that given by the same institutions a century or more ago. The same is true in our own country. Those who have followed even casually our educational history know how very different is the curriculum of such institutions as Harvard to-day as compared with that presented by the same institution during the early years of its existence. The prominence once occupied by Hebrew, Assyrian and Sanskrit has now given place to the study of modern languages and literature; the Greek and Latin requirements have been greatly reduced, and instead history and the social sciences have come to be recognized as important elements of a liberal education. The natural sciences, once represented at Harvard by a brief course in natural philosophy, astronomy, and half an hour a week devoted to botany during the spring months, have gradually been expanded until there is now offered sufficient work in these branches at this institution alone to require the entire time of a student for a dozen years to complete it.

Moreover, the fully equipped modern American university is no longer the traditional college of liberal arts of England, nor is it confined to the four faculties of the continental institutions. We have in addition to these in most of our institutions strong technical departments giving instruction in the various branches of agriculture and engineering.

In technical education America leads the world. Not only was shop-practise, as the laboratory of the engineer, first introduced in this country, but several of the best European technical laboratories have been patterned after those of a leading American institution. This is what we might reasonably have expected. The American people have been and still are busily engaged in the conquest of a continent. Its resources are vast and varied and their development presents a wide range of industrial problems, the solution of which have had, as they should, no small influence upon the character and the trend of our educational institutions. To meet the demand for trained men in the industries, strong engineering schools have sprung up in most of our great centers of population and the states themselves have recognized their obligation and their opportunity by establishing technical schools in connection with their state colleges and universities.

Another condition that is bound to influ-

ence in no small degree the trend of our educational institutions is the fact that our population is rapidly increasing and that the public domain now at our disposal for future expansion is practically exhausted. It is significant in this connection to observe that within the last one hundred years, we have four times doubled our population, and it is a conservative estimation that within the next century we shall be obliged to maintain a population of more than five hundred million people. Should our population ever reach the present density of that of England, for example, a state no larger than Illinois would have within its borders approximately as many people as were living in the entire United States at the beginning of the civil war. With this increased density of population, there are bound to come new and important problems, which it is the part of good educational statesmanship to anticipate.

Certainly one of the most fundamental of these problems is the question of food and the maintenance of the fertility of our soil sufficiently to insure a permanent agriculture. The American people have wisely foreseen that to meet this condition of continued prosperity scientific instruction in agriculture is necessary, and in most of the states magnificent provisions have been made for it and most excellent results have already been obtained.

It is a matter of profound congratulation that our philanthropists and our law makers have exhibited such keen foresight in making ample provision for these important phases of our national development. It is, however, a cause for still more profound congratulation that while providing for these fields of our educational activity, there has been no disposition to sacrifice the opportunity for educational advantages in other lines, including the time-honored liberal professions of law and medicine.

In America, at least, we have come to accept as a fundamental principle that the supreme test of an education is the efficiency of the training it gives the individual to meet the demands of organized society, and at the same time enable him to contribute most either directly or indirectly to the general progress of national life. With our changing conditions in mind, we may well study, therefore, somewhat more closely the general trend of our educational ideals, to the end that we may the better judge what more, if anything, can be done to more fully prepare the coming generation better to meet the demands of the future and to discover, if possible, some of those things which our educational institutions should undertake in a broad and comprehensive manner if they are to promote our national interests to the highest degree and enable America to contribute its full share to the world's progress.

The most potent influence in recent educational movements, the dominant factor which more than any other has led us to modify both the content of our college curricula and our methods of instruction, has been the growing importance of the sciences and the development of the scientific spirit. It has been of fundamental importance in the marvelous strides which we have made in both industrial and technical education and is bound to be still more significant in the continued development of our educational activity in these lines. Significant, however, as has been our indebtedness to the sciences in the affairs of everyday life and in technical education, still more important, from an educational point of view, is the influence which the scientific spirit has exerted upon educational progress in general and in particular upon the character of the work usually accepted for a liberal academic degree. The

popular conception of a liberal education is no longer confined exclusively to the humanities. All are now agreed that the study of the natural sciences affords a training and a discipline quite as worthy of recognition toward the A.B. degree as that afforded by the study of language, philosophy, and mathematics. Moreover, no one can longer lay claim to a liberal education who has not by formal and serious study made himself familiar in a broad and comprehensive way with the fundamental principles of the biological and physical sciences. I hope that no one will understand me as belittling in the least the value and importance of literary studies. These branches of study are essential to the training of any individual, but they present but one side of that training which the world is now pleased to call a liberal education. History, which opens up to us the accumulated treasures of the centuries; economics and the social sciences, which show us the relation of man to man and to organized society; language and literature, which reveal to us the thought and the masterpieces of other tongues and of other peoples, are all essential elements of a liberal education, but none the more so than are the facts and phenomena which show the relation of man to the animate life with which he is surrounded, or to the laws of the inanimate world with which he must deal in every-day life. All of these elements are necessary in the training of any man who would longer lay claim to a liberal education in any significant sense of that term.

When in 1824 there was established a physiological laboratory at Breslau and in the following year Liebig opened at Giessen his chemical laboratory fully equipped for the use of students and investigators, there was introduced into education a new and very important influence. Stimulated by these centers of scientific activity and by the laboratories of Berzelius in Sweden and Gay-Lussac in Paris, the necessity of laboratory instruction spread with great rapidity to the sciences in general until to-day the laboratory as an educational factor, has come to take its place alongside the library as the two most important features in the equipment of a modern educational institution. The introduction of the laboratory and of laboratory methods of dealing with problems of research has introduced in all fields of human thought an entirely new method of attacking problems of investigation. Formerly, when a scholar wished to investigate a subject, he merely sat down and philosophically meditated concerning it. As a mental performance it was not altogether without value, but scientifically the results were not unfrequently of little or no consequence. To-day, due to that scientific spirit which has come to pervade all investigation, the process is quite different. The first business of the investigator now is to determine all the facts relating to the question under consideration and then by a study of those facts to deduce general laws. We must not, however, make the mistake of assuming that the influence of the scientific spirit has been confined alone to the branches of science. It has spread to the study of the humanities themselves; and we have a good deal to say now-a-days about the scientific method of studying history, economics and philology. Indeed, so far has this method been applied to subjects other than the natural sciences, that those branches of study which have to deal with the relations of man to man, both past and present, including therefore economics, sociology and history, are often spoken of as "the social sciences."

I have said enough perhaps to show the importance and wide-spread influence of scientific study so far as it has come to be

a necessary and essential element in the training of a man to best meet the demands of our times and social conditions. It is not sufficient, however, that our educational institutions should provide merely for instruction in the sciences. I wish especially to emphasize the importance of making every provision for scientific research on the part of both students and faculty. Every educational institution, whether supported by public tax or by private endowment, should stand for scientific investigation. It is of fundamental importance not only to that continued growth of both industrial training and technical education so necessary to fit men to direct us in the development and economic use of national resources, but such work is equally important and necessary in the proper training of men who shall direct us in the methods of correct living, who shall tell us how to prevent as well as how to cure disease, and who shall become the guardians of public sanitation and of public health. The substantial basis for continued progress in these lines is the provision we make for research in the physical and biological sciences.

The establishment of great laboratories for the purposes of research has been one of the chief contributions of the last century. Previous to the nineteenth century, the great inventions were brought about not so much as a result of any special scientific training as by mere accident or the practical requirements of the age. During the past fifty years the case has been quite different. The great discoveries have been made in scientific laboratories and as the result of unusual insight acquired by special investigation. As one of our writers has recently put it, "Formerly, *necessity* was the mother of invention, latterly, the tables have been turned and scientific discoveries have produced new practical needs and *created* spheres of labor, industry and commerce."

We are too apt to forget the contribution that research in pure science has made to the general progress of the industries and of the scientific professions. We need to be reminded now and then that the marvelously successful applications of science which have in recent years revolutionized to such an extent our industrial and professional life, have usually been preceded by equally brilliant scientific *research*, although this has been less in the lime light of public admiration. For example, some fifty years ago the scientific world had its attention called for the first time to the significance of the coal-tar products. The initial discovery that directed the attention of scientists to this fruitful field of research was made by a young and then unknown chemist of London. With the use of such time as he could spare from his routine duties as assistant to Professor Hofman, and with an equipment by no means equal to that of our modern laboratories, this brilliant young scientist made a discovery which has since revolutionized several of our leading industries and has influenced nearly every branch of activity. Through the wide range of the applications of these coal-tar products, we have now come to a fuller appreciation of the genius of this young scientist—since known as the distinguished Sir William Henry Perkin. It was a marvelous series of investigations, which have since enabled the commercial world to produce nearly if not quite 2,000 distinct dyestuffs, giving the entire range of color known to man. Not only are they used in coloring fabrics of all kinds, but leather, woods, paper, bones, ivory, feathers, straw and grasses are so changed in hue by means of these dyes as to meet every demand of taste or fashion; and while in beauty and brilliancy they produce

effects surpassing those supplied by nature, they are also in many cases less affected by time and light.

Nor is this all, for from this offensive pot of tar—once a troublesome by-product in the manufacture of coke and gas—not only are the fabrics which we wear and the decorations of our homes made more attractive to us in color, but from the same source there are produced to-day the delicate fragrance of the rose and the violet, as well as the most popular of our flavoring extracts. In the reproductive arts, in photography, in the preservation of foodstuffs, and even in medicine the results have been quite as startling and wonderful. The scientific discovery that has made all of this possible attracted little attention at the time, and doubtless would never have become generally known had it not been for the generous financial support accorded Perkin by his father in putting his results upon a commercial basis. However, its great economic and industrial importance can now be realized when we are told that from one of the 2,000 dyestuffs now manufactured because of it, there has been in a single year a saving to the industrial world of as much as $20,000,000—a sum approximately equal to the endowment of the universities of Harvard or Columbia, and nearly three times that of Yale or Cornell. This wide range of applications could not have been anticipated, but so important and valuable have these products become commercially that by-product ovens recently introduced in the manufacture of coke and gas have made the former by-products the principal sources of revenue.

No less remarkable in their contributions to the permanent good of mankind and no less brilliant as scientific investigations are the famous researches and discoveries of Pasteur. The work which has made his name a familiar one in every country and at every fireside in the civilized world, was not a scientific accident, but the culmination of a lifetime spent in research which had already yielded results of the highest scientific and industrial importance. His revelation of the existence of bacterial organisms in the world about us and his demonstration of the relation of these microscopic organisms to the process of fermentation and putrefaction, had enabled Lister years before, in fact even before investigation had shown the causative agency of bacteria to disease, to make one of the first and most important applications of bacteriology to the prevention of disease by the introduction of antiseptic surgery, a result which has enabled the medical profession to save the lives of countless thousands.

Koch received his early training and inspiration from the investigations carried on under the direction of Professor Cohn in his botanical laboratory at Breslau, and his subsequent researches upon the cholera germ, at the Berlin Institute and his even more important work that resulted in the discovery of the causative bacillus of tuberculosis and the development of tuberculin are too well known to you and their importance in preventing the spread of these dread diseases is too well appreciated to call for further comment.

The investigations of Metchnikoff, the distinguished Russian zoologist and embryologist, certainly place him among those who have accomplished most in the bearing of the biological sciences upon the prevention of infectious diseases. For eighteen years after graduation he was for the most part engaged in embryological and zoological investigation and discovered many important facts now commonly known to scientists in those fields. In these researches he came in contact with the wonderful activity and efficiency of the white corpuscles of the blood in combating disease

germs. As a result of his research we have his doctrine of phagocytosis, which is the basis of the now generally accepted theory of immunity from disease that has enabled us to do so much to reduce the danger of infection from disease.

All will recall the valuable work of Major Ross, of the Indian Army Medical Staff, in demonstrating by patient and persevering experiment the relation of the malaria parasite to a particular species of mosquito; and the investigation of our own Major Reed and his colleagues of the Cuban Commission in connection with yellow fever. The results of both investigations are common knowledge and have done much in making inhabitable by the white man the vast tropical regions of the earth. It is well, however, for us to remember that these brilliant discoveries had been preceded and made possible only by the long and patient scientific study of the mosquito as such, without any thought that the facts obtained by such research should ever have any significance in controlling or eradicating a dangerous disease. As one writer of prominence in the scientific world has put it:

> The biologist has thus come into closer touch than ever with the profession of medicine, and the time has arrived when the professional students of disease admit that they must bring to their great and hopeful task of abolishing the diseases of man the fullest aid from every branch of biological science. I need not say how great is the contentment of those who have long worked at apparently useless branches of science, in the belief that all knowledge is good, to find that the science that they have cultivated has become suddenly and urgently of the highest practical value.

The contributions of scientific research, in recent years, to the general progress of civilization have been indeed noteworthy, and no less gratifying has been the service rendered by science in the development of our national resources and in the growth and the expansion of our industrial and commercial enterprises. There is at this time, however, in response to an awakened public interest, another and equally important development of scientific activity demanding our serious consideration. I have reference to the relation of the sciences to questions of public health and preventive medicine, and it is to this aspect of our educational activity that I wish to direct your attention so far as I may in the time at our disposal.

In these times when we are discussing with great enthusiasm the conservation of our national resources and attempting to insure our continued prosperity by anticipating the problems that will confront us when we shall have become a nation of half a billion people, we are bound to recognize the fact that after all one of the greatest resources of this or any other nation is the preservation and protection of the health of its people. As our former president, Mr. Roosevelt, said in one of his messages to Congress:

> This problem is but a part of another and greater problem to which we as a nation are not yet fully awake, and with which we must grapple in the great contest of nations—*the problem of national efficiency.*

It is but natural that the American people, busy as they have been in the conquest of a continent, should have disregarded somewhat the problems of sanitation and public health to consider first those interests which have developed our industrial life and established our commercial standing. The time has forever passed, however, when a man may be regarded as fulfilling his entire duty when he protects the members of his immediate family from the inroads of disease. It has become a matter of public concern as to how far we shall allow our families or our community to be exposed, through the ignorance or carelessness of others, to infec-

tious diseases or to contaminated and adulterated food supplies. We do not as yet fully realize the value of human life as a public asset. To estimate the financial value of a human life to the community is no more difficult as a mathematical problem than to compute an insurance premium or to adjust a loss from fire. Judged from the standards set by the decisions of the courts of our country, reflecting as they do in a way the opinion of the American people as to the value of human life, it is conservative to say that the state of Illinois, for example, lost during 1907 more than $1,500,000 by deaths from typhoid fever alone, a disease which, as we all know, is due largely, if not wholly, to a neglect of the proper laws of sanitation. Every death from a preventable disease appears upon the debit side in the trial balance of a community or of a nation. Commissioner Evans, of Chicago, estimates that 45 per cent. of the deaths last year in that city were caused by preventable diseases. It is now nearly half a century since the strife between the north and the south culminated in that memorable and bloody conflict known as the civil war. Nearly every hearth-stone tells the sad story of a broken family circle and the nation still mourns the long list of her heroic dead. Tremendous as was the loss of life in those eventful four years, it is a significant fact to be observed in this connection that 25 per cent. more deaths occur every year in this country from tuberculosis than the total loss of all of the union forces in battle and from wounds during the entire four years of the civil war. Unless this disease is checked, it is said that there are 5,000,000 of people now living in the United States who are destined to a premature death from this one cause. It is difficult for us to realize the enormous loss to the wealth of the country which this involves. A most careful study of this aspect of the question has been made by Professor Glover, of the University of Michigan. He has shown upon what would seem to all of us, I am sure, a very conservative estimate of the earning capacity of the individual during the working years of his life, that the annual financial loss to the United States is more than $36,000,000—nearly twice the total bi-ennial income of the state of Illinois. In other words, the United States could well afford to spend $36,000,000 each year if thereby this disease could be brought under the same control as are other preventable diseases.

Much has been accomplished and more is now being undertaken in the control of diseases by our state and municipal boards of health. However, their efforts are directed for the most part to applying known results and methods to preventing the spread of diseases rather than to the serious study of the *scientific problems* arising from unhealthful conditions. Much is also being accomplished by the scientific departments of our educational institutions, but the provision for scientific research in these lines is altogether inadequate for future needs and for the magnitude of the opportunity at hand. We are not doing for the public and private health of our people anything like what we are doing for the development of our commercial and industrial interests. We have in all our states and territories agricultural experiment stations, some sixty in all, the main function of which is the investigation of questions relating to the promotion and preservation of our national agricultural interests. A magnificent and important work is being accomplished at a public expense of millions of dollars annually, employing for this purpose more than a thousand people. There is no doubt in the mind of any public spirited man or

woman that it pays to make this expenditure for the promotion of interests so important. A bill was introduced in the last congress asking that similar provision be made in each state for an engineering experiment station which should undertake the scientific study of those problems which are fundamental to the material and industrial development of our country. All are glad to see these provisions made, for we all not only have a pride in the industrial and commercial prosperity of the country, but we are all directly or indirectly connected with it and depend upon it.

Why should we not do as much, however, to promote the conditions for healthful living among our people as to stimulate the development of our national resources? But few of us are agriculturists, and not all are directly concerned in the prosecution of industrial enterprises needing the assistance of a trained engineer, but every one of us, irrespective of vocation, is vitally concerned with those scientific facts that mean better sanitation, better facilities for overcoming and preventing the spread of infectious diseases, in short, with all that knowledge which will enable us to live better, longer and happier.

Until within the last ten years there was not a single institute for medical research in America, although France, Germany Russia and even Japan had such institutions. These institutions and others of a similar character have rendered an important and valuable service to medical science and to mankind. Since the opening of Pasteur Institute, for example, in 1888, more than 25,000 people have been treated for hydrophobia at the Paris Institute alone, to say nothing of the thousands who have been saved from the terrible consequence of this disease the world over by the methods perfected by Pasteur. To have cured such an army of human beings is enough honor for any institution and sufficient cause for its foundation. The influence of the institute however has not ended here. It is essentially a school of bacteriology where the student and the investigator are given instruction and afforded an opportunity to extend both his personal knowledge and that of the world in the application of science to the cause and prevention of disease. It was here that Calmette, the discoverer of serum treatment for serpent-poisoning, and Yersin, whose famous researches in the prevention and cure of cholera are known to all, received their training. The institute has always had associated with it some of the best scientific investigators of the world. Here Roux did the work which will forever connect his name with the serum treatment of diphtheria, and Chamberland has directed the work in economic bacteriology in its applications to hygiene, including the development of serum for the various diseases of domestic animals by which it is said that a million sheep and half that many cattle are annually given immunity from anthrax. Here also Metchnikoff has carried on his investigations which have done so much to improve human conditions by immunity from disease.

The record of achievements at the Pasteur Institute is typical of those of the Berlin Institute of Hygiene and others which have been founded for similar purposes. There is no need to multiply illustrations. All are familiar with the results and know something of the work of the large number of brilliant investigators who have thus been enabled to give their time and attention to this fruitful field of research.

Within the last ten years substantial progress has been made in America in pro-

viding for scientific research along lines which have a direct bearing upon the practise of medicine. We now have among others the Rockefeller Institute for Medical Research in New York with its endowment of $3,000,000;[2] the Laboratory for the Investigation of Cancer at Buffalo, supported by the state of New York; the Phipps Institute for the Study of Tuberculosis at Philadelphia, and the Institute for Investigation of Infectious Diseases, endowed by Mr. and Mrs. McCormack, of Chicago. No more commendable or fruitful field for the philanthropist can be found in any sphere of educational activity than in providing the financial support needed for such institutions. I can see no reason, however, why we should leave such an important field of inquiry wholly to the generosity of public-spirited men and women. Legislative bodies are becoming interested and are willing to provide means for the study and control of preventable diseases. Twenty-eight of the forty-three state and territorial legislatures in session two years ago passed laws concerning tuberculosis, and ten states have recently made appropriations amounting in the aggregate to $100,000 to be used exclusively in the education of the public concerning this disease. Much has been done and is now being accomplished by the scientific bureaus at Washington. The Bureau of Chemistry, through the pure food and drug act, the Marine Hospital Service, and others are devoting much attention to the problem of protecting the health of the public. In April President Taft sent a message to congress recommending an appropriation of $50,000 for the purpose of establishing a laboratory for the investigation of cancer. Most important of all, however, is the bill recently introduced in congress by Senator Owen providing for the organization of all of these activities of the government into a department of public health.

The general government might well afford to spend a relatively much larger portion of its income upon those scientific investigations that have for their purpose not only the elimination of unhealthful conditions and the protection of our nation from the dangers of impure food supplies, but also the development of preventive medicine. We are in these times quite as much interested in the prevention as in the cure of disease, and it is a sad commentary upon us as a nation that 72 per cent. of our national income is being spent in preparations for war and because of past wars, leaving only 28 per cent. available to meet all other expenses of the government. The average annual expenditure upon the army and navy for the past eight years, that is, since the close of the Spanish war, is sufficient to establish a three million dollar Rockefeller Institute in every state and territory of the union and still leave more than the amount of the present magnificent endowment of Pasteur Institute of Paris. Many of the state governments are likewise spending an abnormally large proportion of their revenues upon the non-productive classes. About 40 per cent. of the revenues of Illinois is being spent in caring for those who are either morally, mentally or physically incapable of the full responsibilities of citizenship in a free and democratic commonwealth. Illinois is no exception in this respect. It is a noble and a necessary work to provide for these non-productive classes in the state and in the community, but as I have said, we are to-day quite as much interested in the prevention as in the cure of disease, and doubtless no small portion of our non-productive classes are such be-

[2] Recently increased by an additional gift of $3,820,000.

cause of a diseased condition of mind or body which might have been avoided if they or their parents had better understood the principles of correct living. In order to promote the best interests of the state and to increase the efficiency of our productive classes, as well as to prevent in the future a further increase in the nonproductive elements of our people, it is desirable to establish in this state, and in every state alongside of our agricultural experiment stations and our engineering experiment stations a great experiment station of sanitary sciences and preventive medicine. Such an experiment station should undertake to supplement the work now being done by our state and municipal boards of health. The principal function of these boards is to prevent by advice and by process of law the spread of contagious diseases and to supervise in a general way the sanitary conditions under which we live. This is valuable and important work, but it is not sufficient. We should have a body of trained investigators whose sole purpose should be to study in the light of biological science the data thus being collected from the various communities of the state and to supplement the same by special investigations whenever found necessary, to the end that there should be brought to bear upon the cause and prevention of unhealthful conditions all the results which scientific investigation can give. The long list of accomplishments of such institutes as have already been mentioned furnish abundant evidence of the value and importance of such research. Suppose, for example, such investigation should result in a discovery comparable to Behring's discovery of the treatment of diphtheria by antitoxic serum—a result by which in the last twelve years the mortality from this disease has been reduced to one fifth of its former rate. Contemplate for a moment the benefits which would come to the human race from a discovery of a means of preventing or curing pneumonia, an infection from which, I am told, as many die to-day as did a hundred years ago in spite of all the work which had been done upon it; or what a boon it would be to humanity if the cancer should be brought under control as have been smallpox and hydrophobia.

Such an experiment station should include a laboratory of physiological chemistry in which questions of human nutrition and problems growing out of it should be investigated—work not unlike that now being done by Professor Chittenden at New Haven, or that which was done by Professor Atwater at Middletown, and that which is now being carried on at the University of Illinois under the direction of a national commission of physiologists. It should include a bacteriological laboratory, fully equipped to carry on extensive investigation in the various branches of this comparatively new science and particularly to study its applications to the cause and prevention of diseases. Such an experiment station should be equipped with a laboratory of sanitary science in which the problems arising from water supplies, sewage disposal, sanitation and the relation of all of these to public health should be fully investigated. And finally there should be included a department of medical research, not that it should teach this or that system of medical practise, or be primarily a teaching body at all, but that it should undertake the investigation of the cause and prevention, as well as of the cure, of such diseases as have as yet not yielded to medical treatment.

Equally important, and that quite apart from the provision for scientific research upon problems of public health, is the provision we should make to educate the gen-

eral public as to the sources of danger, and the importance of protecting the community from the carelessness of the ignorant few. The results of scientific research are of no great consequence without that public sentiment which insures the application of these results for the benefit and the protection of all. In spite of the fact that science has long since determined the cause and the means of preventing the spread of the bubonic plague, it still rages in India simply because the great masses of the people of that country choose to regulate their personal habits in matters of cleanliness and sanitation according to the rules of the Brahmanistic religion rather than in accordance with the results of modern science. Ten thousand people in Chicago are to-day suffering from tuberculosis, pauperizing that city, as Commissioner Evans declares, to the extent of more than $20,000,000 a year, not so much because science has failed to suggest means of improvement as because of the ignorance of those afflicted and the lack of sufficient public sentiment to enable the authorities to compel property owners to provide the proper sanitary conditions.

What is needed most in the public health movement is an intelligent appreciation on the part of the leading citizens of our various communities of the necessity of suitable legislation and the proper enforcement of sanitary conditions. Montreal's recent experience with a smallpox epidemic illustrates the sad consequence from ill advice at a critical time. Due largely to the influence of a physician who had gone wrong scientifically a general sentiment against vaccination had developed and when a Pullman porter carried the disease to that city a general epidemic resulted, causing the death within ten months of 3,164 persons, most of whom were children under ten years of age. Contrast with this record that of Chicago for last year. Here in a city with ten times the total population of Montreal and with every opportunity for importing the disease through its great avenues of passenger traffic and its transient population, under the influence of public pressure better conditions prevailed. Thirty thousand deaths occurred last year in Chicago, but not a single death from smallpox, although numerous instances occurred where people coming to the city brought the disease with them.

Chicago, by the way, presents a good illustration of what a thoroughly scientific and efficient leadership can accomplish in protecting a community from unhealthful conditions. In 1891 that city had the largest death rate from typhoid fever of any city in the civilized world. To-day with its better facilities for the disposal of sewage, better inspection and protection of its water and food supplies, it is comparable in this regard with any other large center of population in this or any other country. In fact, Chicago now has the lowest death rate of any American city of more than 350,000 inhabitants. It is no small problem to undertake the inspection of the food supplies of a great city. For example, the milk supply of Chicago comes from four states and not unfrequently it is shipped a distance of more than fifty miles. It takes more than 240,000 gallons of milk a day to supply the city and this supply is produced upon 12,000 different farms and by more than 120,000 different cows. Yet in this great metropolis, the city ordinances provide for a careful inspection of the various food supplies; for example, no meat may now be offered for sale in the local markets of that city until it has received the stamp of approval of a city or government inspector. The advance made by Chicago within the last few years is due in a very large measure to the untiring

energy and the efficient leadership of Commissioner Evans and his colleagues.

As I have already remarked, what we need in every community is an intelligent and efficient leadership in this as in other matters of public concern. This need necessitates not only a training that will give us the few high-grade specialists who shall become our public health officers, but a training which may well be regarded as an essential element in the education of every man and woman who is to occupy a place of influence in the councils of the community and of the nation. Where shall we look for such training if not to our colleges. There should be in every college course required work of the character indicated and every college should have its department devoted to instruction in matters of sanitation and preventive medicine, not as an annex to some other already overcrowded department, but as a separate department with its full quota of instructors and provided with suitable laboratories. It may be of interest in this connection to observe that within the past two years great interest has been manifested not only by our leading medical schools, but by our colleges of liberal arts in extending their offerings in this line. Cornell is perhaps the best illustration of what can be accomplished in a popular way. Last year, the members of the faculty of that institution, in cooperation with the New York State Board of Health, conducted a course of lectures, extending throughout the year, upon the general problems relating to public health. The course proved to be very popular with the student body and was so largely attended both by the students and the citizens that at times standing room in the auditorium was at a premium. Similar courses have been either introduced or are now under discussion at several of the other leading institutions of the country. So far as I know, no institution has yet established a department of public health and preventive medicine. It is a development, however, that is bound to come in the immediate future and it is only a question as to what institution shall claim the honor of priority.

By way of conclusion, may I once more emphasize the important rôle that the sciences have played in our national progress and in the trend of our educational institutions, reflecting as these institutions do, not only the demands of a progressive people, but the requirements of an expanding and unfolding future.

Above all, the chief purpose of science is service, whether that service be in the development of the national resources of a country or in aiding the growth and expansion of its industries and of its commercial power; or whether it be in the conservation of those resources that constitute the inherited wealth of a people. In the great contest of nations, matching the efficiency of one people against that of another, no service is more important than that which science has rendered and is still to render in the preservation and protection of human life against the inroads of unnecessary and preventable disease. May you as students and teachers of the biological sciences, devoted as you are and should be to the development of these sciences in their broadest aspects, and all of us as citizens of a country that never hesitates to provide generously for those things that are for the general good and that contribute to national prosperity and success, lend a helping hand, to the end that our educational institutions and our country may stand foremost among those institutions and those nations contributing most to the great service which this generation shall render to the general progress of mankind.

E. J. Townsend

University of Illinois

THE FIELD SESSION OF THE SCHOOL OF AMERICAN ARCHEOLOGY[1]

The School of American Archeology was created in 1907 by the Council of the Archeological Institute of America, with the object of organizing and giving direction to the study in America of this and cognate branches, constituting the science of man in a broader sense—anthropology. It is controlled by a managing committee appointed by the institute, consisting of thirty-three prominent citizens and scientists of Canada, the United States and Mexico; and its field of activity embraces those countries, with the addition of Central America. After canvass of various localities the school was located at Santa Fe, New Mexico, because it is in the heart of a vast region of prehistoric cultures upwards of 1,000 miles long by 800 miles wide, extending from Utah to southern Chihuahua. It thus dominates a typical field for the investigation of the character and probable origin of the native races of this continent. The advantage to the school of having such an environment of original material for study is obvious.

As a further addition to the facilities of the school, the territory of New Mexico established at Santa Fe the Museum of New Mexico, to be administered by the director of the school, and for that purpose donated the historic palace of the governors, one of the oldest public buildings in the United States, with an annual fund for its maintenance. This has now been partially installed, and was formally opened to the public August 20; it will furnish collections, laboratories, lecture and research rooms, for the current work of the school.

The general plan of the school contemplates that a portion of each year's work shall be done in the field, in direct contact with the things to be studied. The first fully organized session under this plan was held during the past summer, in the region tributary to Santa Fe, under the personal direction of Dr. Edgar L. Hewett, Director of American Archeology, and of the school. Four months were devoted to the general work, distributed as follows: One month to field work in the Ojo Caliente Valley; two months to school and field work at the Rito de los Frijoles; one month to field work in the Jemez Valley. The United States Bureau of Ethnology collaborates with the school during four months of field work and two months for preparation of reports, under the joint authority of the chief of the bureau and the director of the school. Mr. F. W. Hodge, chief of the bureau under the title of ethnologist in charge, took part in the work personally during the latter part of the season. The bureau, however, has nothing to do with the administration or maintenance of the school—the collaboration above mentioned being arranged for mutual benefit, and to avoid duplication of work in the field.

The school is now permanently established. Sessions will be held annually at different points within the general region, to be designated from time to time according to the localities under investigation. As the session recently held fairly illustrates the practical working of the school as organized, some account of it will be of interest.

The members of the *Staff of Research and Instruction* were: Dr. Edgar L. Hewett, director (University of Geneva); Mr. John P. Harrington, ethnology and linguistics (Stanford, Berlin, Leipzig); Mr. Sylvanus G. Morley, archeology (Harvard).

Special Assistants: Mr. Junius Henderson, geology, zoology (University of Colorado); Mr. W. W. Robbins, botany (University of Colorado).

Special lectures were given by Mr. Hodge, chief of the Bureau of Ethnology, Professor McCurdy, of Yale, and Mr. K. M. Chapman, of the school.

The actual working force consisted of the director, Mr. Hodge and twelve assistants, including the regular members of the school staff, and a number of teachers and students from the universities of Utah, Colorado, Cornell, Denver and Oxford, England. A well-equipped library, with study and lecture tent

[1] Held near Santa Fe, N. M., June–September, 1910.

and awnings, was provided. Lectures and field excursions, under direction of some of the staff, were held at stated hours; these were regularly attended by many visitors, including tourists and travelers from various parts of the country, and prominent officials and citizens of Santa Fe. Many of these came out of curiosity, but availed themselves of the facilities afforded by the lectures and excursions, which were free to all who were interested. The locality is about thirty-five miles by road from Santa Fe, reached by carriage in a day's drive.

The line of research followed embraced the usual archeological work, having for its aim the study of the native races of America, limited at present to those of fixed habitations. For this there are two sources of knowledge: (1) The original, from the prehistoric ruins, representing the isolated Indian culture unmodified by contact with other races; and (2) secondary, from the existing Indians of contiguous or related territory, who must be studied for the light they throw on the ancient cultures. Under the plan developed in the school, these problems are attacked with aids derived from several branches of science, some of which at first thought may not be considered germane to the subject; but a suggestion of the reasons for employing them will show their relevancy. Under the general head of ethnology we may have:

1. *Linguistics.*—The languages of the living Indians of the region furnish trails leading to knowledge of many things we need to know concerning the ancient peoples—their knowledge of places, geographical limits, the elements, constellations; their ideas on myths, legends, religion; their views of life and the hereafter; their social organization and material culture; the whole range of what they make and do, and why.

2. *The Natural History of the Region.*—(*a*) *Geology.*—The settlement of the whole great southwest region of 1,000 by 800 miles was directly controlled by the geological structure of the country. It determined the location of the habitations; the building material and character of the houses, from the caves worn by the winds out of soft tufaceous deposits, enlarged by scratching with stone tools, to additions and enlargements with shaped blocks upon the talus, leading later to the detached houses as population increased, and finally to the Pueblo houses of to-day. These are ethno-geological facts closely related to the questions in hand.

(*b*) *Vegetation.*—Plant life powerfully influenced the culture of the Indian. He made use of a large number of them, for their food value, their medicinal properties real and supposed, and for superstitious reasons. He was in this region necessarily an agriculturist, depending upon vegetation for his subsistence far more than the plains Indians, who had animal food in abundance. To understand this properly, exact knowledge of the plant life of the region is necessary, together with the probable effect upon it of great cycles of climatic change. Scientific knowledge of the present day must be connected with what the Indians knew of the plants. To know exactly what plant was used by them, for a certain purpose, is an ethno-botanical fact that is pertinent.

(*c*) *Animal Life.*—An accurate knowledge of this, both past and present, is important for its bearing upon the food-supply, and the beliefs of the Indians concerning the animals; these were endowed by them with a great variety of attributes, some of them human, belief in which greatly affected the life and superstitions of the people. Therefore the animal life of the region must be studied scientifically in order to know it accurately ourselves, and we study it ethnologically to learn the beliefs of the Indians connected with it; we correlate the two in search of ethnozoological data.

Coordinated with these, in such a way as to form definite and manageable units, the accumulation of which is expected to furnish a solid basis for future generalizations, there is provided—

3. *An Archeological Survey of a Definite Region.*—This embraces the study of the distribution of the ruins, relating to the social organization and life of the people; the plan

and construction of the buildings, showing their home life and religious practises; the domestic utensils and tools, indicating their industrial development; decoration, showing the origin and progress of their ideas of design and ornament, bearing upon the evolution of beliefs and habits of thought.

All these lines of research lead up to the most important phase of the inquiry, viz.,

4. *Psychology.*—For it is the human mind that we are studying, and the ultimate aim of these correlated investigations is to find out how the mind of man has been influenced by his environment; how his beliefs and life have been created, modified, continued, or destroyed by his physical surroundings.

The methods adopted for carrying out the foregoing scheme, and which were successfully practised during the recent summer session, may be summarized as follows:

1. Excavations of the designated ruins, systematically made under proper supervision; insuring the adequate scientific record of all facts disclosed, care of the objects discovered, and preservation of the structures for the use of future students.

2. Special investigations upon the collateral subjects above indicated, made by persons thoroughly qualified, within the definite region under consideration. These embraced the survey and mapping of the area; and the geology, botany and zoology, studied in direct connection with the linguistics of the existing Indians derived largely from the same stock as the ancient dwellers. This was accomplished by taking a number of intelligent Indians into the field, and learning from them at first hand the original names of all the objects studied, their uses, and the beliefs and traditions concerning them.

3. Daily class excursions under instruction, bringing the students from time to time into direct contact with the researches mentioned in the last two paragraphs, thus affording opportunity for study where the things are, and for discussion in their presence.

4. Facilities for direct comparison of pertinent literature, by means of a library on the spot.

5. Intelligent presentation of the results of the work, and of related questions, by means of daily lectures, with opportunity for inquiry and discussion following them.

The foregoing program of field study will be followed by work at the museum during the year, where the material obtained in the field will be digested, and the results prepared for publication. This will include, among the special features, phonographic and kymographic studies of languages now rapidly disappearing, thus securing mechanically accurate records for future use.

FRANK SPRINGER

SCIENTIFIC NOTES AND NEWS

ANNOUNCEMENT is made that the Nobel Prize in medicine for 1910 has been awarded to Dr. Albrecht Kossel, professor of physiology at Heidelberg.

AT its last meeting the Rumford Committee of the American Academy made the following grants: to Mr. P. W. Bridgman, of the Jefferson Physical Laboratory, Harvard University, $400 additional, in aid of his research on the thermal and optical properties of bodies under pressure; to Professor Charles L. Norton, of the Massachusetts Institute of Technology, $400, in aid of his research on thermal insulation.

THE Royal Scottish Geographical Society will award its medal to Professor James Geikie, F.R.S., for his contributions to geographical research and his services to the society; and the Livingstone gold medal to Sir John Murray, K.C.B., F.R.S., in recognition of his oceanographical work.

AT Cambridge University the Gedge prize has been awarded to G. R. Mines, of Sidney Sussex College, for his essay entitled "Researches on the Physiological Action of Inorganic Salts chiefly in Relation to the Cardiac and Skeletal Muscles of the Frog."

M. LACROIX, professor of mineralogy at Paris, has been elected a corresponding member of the Vienna Academy of Sciences.

MR. JOHN RANDALL, of Maidley, England, who has made various contributions to geology

and to the history of the clay industries in Great Britain, celebrated on September 1 his hundredth birthday.

DR. DUDLEY P. ALLEN has retired from the chair of surgery in Western Reserve University and will leave Cleveland for an extended trip abroad. The trustees have passed a resolution in which they say: "Upon the medical school of the university, to which his father and his grandfather gave their labor, he conferred distinction, as well as giving professional and personal devotion." Dr. Allen has been appointed professor emeritus.

DR. KENDRIC CHARLES BABCOCK, president of the University of Arizona, has been appointed specialist in higher education in the United States Bureau of Education, to fill the new position created by the present congress at its recent session.

DR. DAVID H. RAY, who has had charge of the engineering courses in the College of the City of New York, has been appointed chief engineer of the Bureau of Buildings of the Borough of Manhattan, New York City.

PROFESSOR A. N. TALBOT, of the College of Engineering of the University of Illinois, is serving as a member of an expert commission which is engaged in inspecting and reviewing the work of construction of the new City Hall of Chicago.

DR. C. A. CRAMPTON, after serving twenty years as chief chemist of the Internal Revenue Bureau of the Treasury Department and prior to that time seven years in the Bureau of Chemistry of the Department of Agriculture, has retired from the government service for the purpose of engaging in private practise.

DR. K. MIYAKE, Ph.D., Cornell, 1902, is spending a couple of months at the laboratory of the department of plant pathology of the New York State College of Agriculture, studying the diseases of ginseng. Dr. Miyake is a lecturer in the department of botany in the Imperial University of Tokyo. He has been sent here by the Korean government along with Mr. M. Tomiiye to investigate the cultivation and particularly the diseases of ginseng. Ginseng is under a government monopoly in Korea and during the past few years there has been a remarkable reduction in the out-put, due to the diseases of the roots. Similar diseases affect the crop in this country. There is an export annually from the United States of about a million dollars worth of ginseng. A large portion of this is cultivated, a considerable part of it being grown in the state of New York.

PROFESSOR DAVID EUGENE SMITH'S "History of Decimal Fractions," published by Teachers College, Columbia University, in March, has been translated into Japanese.

ON October 15 and 16, Professor D. W. Johnson, of Harvard University, conducted a geological excursion to Truro and Provincetown, to study the shore lines and sand dunes of Cape Cod.

SIR FRANCIS LOVELL, dean of the London School of Tropical Medicine, intends to make a tour on behalf of that institution during the winter, visiting the Bahamas, Bermuda and British Honduras.

DR. GEORGE KERSCHENSTEINER, superintendent of schools of Munich, will make an address at the meeting of the Society for the Promotion of Industrial Education, to be held at Boston beginning on November 17.

PRESIDENT ERNEST FOX NICHOLS, of Dartmouth College, was announced to read a paper on "Modern Physics" before the American Philosophical Society on the evening of November 4.

PROFESSOR EUGEN OBERHUMMER, of the University of Vienna, is giving a series of about twenty-four lectures at the University of Chicago, on "The Political Geography of Europe." He addressed the Geographic Society of Chicago at its regular October meeting, on the subject, "The Political Geography of Austria-Hungary."

MR. FREDERICK A. DELANO, president of the Wabash Railroad Company, addressed the students and faculty of the College of Engineering of the University of Illinois on Tuesday, October 25. His subject was "The Railway as a Profession."

The October number of the *Irish Naturalist*, as quoted in *Nature*, contains obituary notices of Samuel Alexander Stewart, who was born in Philadelphia on February 5, 1826, whence he went in 1837 with his father to Belfast, where he eventually worked as a miller. Details of his life and work are recorded in two separate articles in the serial quoted, the former being described by the Rev. C. H. Waddell and the latter by Mr. R. L. Praeger. Most of his papers were devoted to botanical subjects, although local zoology likewise claimed a share of his attention. Mr. Stewart died on June 15 last as the result of a street accident.

It is proposed to erect in the new chemical building of the University of Michigan a bronze tablet in memory of Dr. Albert B. Prescott, for many years director of the chemical laboratory.

A drinking fountain, designed by Professor R. Tait MacKenzie, of the University of Pennsylvania, has been erected at the Central Experiment Farm, Canada, in memory of Dr. James Fletcher, former Dominion entomologist and botanist.

David Pearce Penhallow, professor of botany in McGill University and eminent for his contributions to paleobotany, died on October 26, at the age of fifty-six years.

Robert W. McFarland, emeritus professor of civil engineering in the Ohio State University, died on October 24, at the age of eighty-five years.

Professor Carl Svante Halberg, professor of pharmacy in the medical school of the University of Illinois, died on October 22, at the age of fifty-four years.

Professor Melchior Treub, for twenty-nine years director of the Buitenzorg Botanical Garden in Java, has died at the age of fifty-nine years.

Dr. Sydney Ringer, F.R.S., sometime Holme professor of clinical medicine at University College, London, has died at the age of seventy-six years.

Trelawney William Saunders, for many years assistant geographer to the Indian Office under the British government and known for his contributions to geography, has died in his ninetieth year.

Dr. Thorvald Nicolai Thiele, professor emeritus in the University of Copenhagen and formerly director of the Copenhagen Observatory, known for his contributions to actuarial science as well as to astronomy, died on September 26, at the age of seventy-two years.

Dr. R. Geigel, professor of physics and geodesy at the Aschaffenberg Forest School, has died at the age of fifty-four years.

Dr. B. Raymann, professor of chemistry in the Bohemian University at Prague, has died at the age of fifty-eight years.

The deaths are announced in *Nature* of Mr. John Roche Dakyns, formerly of the British Survey; of Dr. F. W. D. Fraser, formerly professor of anatomy and physiology at the Imperial University of Osaka, Japan; of Mr. A. H. Stokes, until recently chief inspector of mines in the Midland district, of England, and of Mr. Cecil H. Leaf, known for his studies of cancer.

Section F of the American Association for the Advancement of Science will join with the Central Branch of the American Society of Zoologists for the reading of technical papers at Minneapolis, Tuesday, December 27, and Wednesday, December 28.

The twenty-eighth stated meeting of the American Ornithologists' Union will be held in Washington, D. C., beginning November 14, 1910. The business meeting will be on the evening of that date, for the election of officers and members and the transaction of routine business. The public sessions, devoted to the presentation and discussion of scientific papers, will be held in the auditorium of the new U. S. National Museum, November 15 to 17 inclusive, from 10 o'clock A.M. until 4 P.M. each day. Information regarding the meeting can be had by addressing the secretary, Mr. John H. Sage, Portland, Conn.

"The Volatile Matter of Coal" is the title of the first bulletin to be issued by the new federal Bureau of Mines. The authors, Hor-

ace C. Porter and F. K. Ovitz, conducted their investigations at the Pittsburgh station while it was under the technologic branch of the Geological Survey, the work being a continuation of the fuel investigations begun several years ago at the Louisiana Purchase Exposition, St. Louis, Mo. The results obtained at that plant showed that the work of determining the fuel values of the coals and lignites in the United States with a view to increasing efficiency in their utilization would be incomplete if it did not include systematic physical and chemical researches into the processes of combustion. Hence in their later investigations the authors carried on such researches, concentrating attention on those lines of inquiry which promised results of economic importance. This bulletin is a report on an investigation of the volatile matter in several typical coals—its composition and amount at different temperatures of volatilization.

UNIVERSITY AND EDUCATIONAL NEWS

THE state legislature of Arkansas has appropriated $350,000 for the erection of four agricultural schools and $500,000 additional has been raised by the cities.

AT the recent meeting of the board of directors of Washington University it was announced that a research laboratory in connection with the chair of pathology and therapeutics in the dental school has been endowed. A well equipped laboratory will be in thorough working order at the beginning of the annual session, October 1, 1910. Dr. Hermann Prinz, who has filled the chair of dental pathology and therapeutics for the past ten years, has been chosen to take charge of the new laboratory.

AT a recent meeting of the board of regents of West Virginia, the College of the State University was discontinued, and a department of medicine in the College of Arts and Sciences was established. This department will, as heretofore, offer the work of the first two years of the medical course, but the university will not award the degree of M.D. to those of its students who complete the last two years in medicine at certain other colleges, as has hitherto been done. This preliminary medical work will be improved, and may be counted towards the degree of B.S.

AT the College of Agriculture of the University of Wisconsin and the Wisconsin Agricultural Experiment Station Dr. Ormond S. Butler has been appointed instructor in horticulture to give his entire time to research work. Dr. Butler received his doctor's degree at Cornell in 1910 where he specialized in plant physiology. Dr. Frank B. Hadley has been appointed assistant professor of veterinary science. Assistant Professor E. R. Jones has been granted leave of absence for the second semester to study soil physics and drainage in this country and abroad. Conrad Hoffmann, assistant in agricultural bacteriology, who has been on leave of absence for a year studying soil bacteriology, in Germany, has returned and is giving a course in soil bacteriology.

MRS. HELEN THOMPSON WOOLLEY is assisting in the department of philosophy of the University of Cincinnati this winter.

DR. W. B. PILLSBURY, of the University of Michigan, has been advanced to a full professorship of psychology.

DISCUSSION AND CORRESPONDENCE

THE MENDELIAN THEORY OF HEREDITY AND THE AUGMENTATION OF VIGOR

TO THE EDITOR OF SCIENCE: One of the most interesting questions in connection with the Mendelian theory of heredity is whether the augmentation of vigor observed in crossing distinct varieties can be explained on the hypothesis of the pure gamete.

The following mathematical treatment of the subject may be of interest to some of your readers.

The most general expression for a Mendelian family breeding true to its mean is

$$(p^2(DD) + 2pq(DR) + q^2(RR))^n$$

for, if the array of individuals obtained by expanding this expression be crossed at random, we get the same expression for the array of offspring generation after generation.

If we take two "breeds" denoted by

$$\{p^2(DD) + 2pq(DR) + q^2(RR)\}^n \qquad (a)$$

and

$$\{P^2(DD) + 2PQ(DR) + Q^2(RR)\}^n \qquad (b)$$

respectively, and cross them at random, it is not difficult to show that the array of the resulting hybrid offspring is given by

$$\{Pp(DD) + (Pp + pQ)(DR) + Qq(RR)\}^n \; (c)$$

Now, the mean number of recessive elements in these families is

$$(a) \qquad \frac{q^2}{(p+q)^2} \times n$$

$$(b) \qquad \frac{Q^2}{(P+Q)^2} \times n$$

$$(c) \qquad \frac{qQ}{(p+q)(P+Q)} \times n$$

Thus the mean of (c) is the *geometric* mean of (a) and (b).

Since the geometric mean is always less than the arithmetic mean, it follows that the mean number of recessive elements (of the type (RR)) in (c) is less than the collective mean of the families (a) and (b) treated as one population. Moreover, since the recessive elements are fewer, the aggregate elements of the types (DD) and (DR) must be greater.

If, now, it be assumed that dominance is positively correlated with vigor, we have the final result that the crossing of two pure breeds produces a *mean* vigor greater than the collective mean vigor of the parent breeds.

By similar methods it can be shown that the "inbreeding" of a Mendelian population leads to a decrease in the mean number of elements of the types (DD) and (DR).

I am aware that there is no experimental evidence to justify the assumption that dominance is correlated with a "blending" character like vigor; but the hypothesis is not an extravagant one, and may pass until a better takes the field.

A. B. Bruce

The School of Agriculture,
Cambridge, England,
August 27, 1910

THE INHERITANCE OF BODY HAIR

Reading a book on South African stories called "By Veldt and Kopje," by William Charles Scully (London, T. Fisher Unwin, 1907), I was struck by a statement which may be of interest alike to anthropologists and students of "Mendelism," and as the book may not have been seen by either, I will quote the passage.

In a chapter on "Kaffir Music," written jointly by Mr. Scully and his wife and originally published in the *Pall Mall Magazine,* incidental mention is made of Madikanè, once reigning chief of the Baca tribe of Bantus, who was killed in battle on December 19, 1824. The Bacas lived on and about the present site of Pietermaritzburg, Natal, until driven into exile by the Zulus or the Amangwanè.

> There is some ground for thinking that Madikanè's mother was an European, possibly a waif from one or other of the vessels which are known to have been wrecked on the east coast of southern Africa toward the end of the last century.
>
> All authorities agree that Madikanè was of great stature, that he was light in color, and that his hair and beard were long. It was his habit to carry his snuff-spoon stuck in the hair of his chest. One of the writers has examined a number of his male descendants, and found about *one in every four* with traces of hair on the chest. It is, it may be stated, very unusual to find any hair on the body of a Bantu. [The italics are mine.]

John Burtt-Davy

THE REFORMED CALENDAR AND A UNIVERSAL SABBATH

To the Editor of Science: The reform of the calendar is at present so hopelessly academic, that it may not be amiss to add another thought. The Jewish Sabbath, or seventh day of rest, has been adopted by both Christians and Mohammedans—but with changes of the actual week-day in order to emphasize division.

In the proposed new calendar the old regular recurrence of named-days would be altered by the odd no-day yearly, and the actual Sabbath-succession destroyed, despite the re-

tention of the pagan names "Friday," "Saturday," "Sunday." If, however, names of the week-days were abolished and they were called, as by the Friends and the primitive Christians, as well as by the ancient Hebrews, first day, second day, etc., up to seventh day, perhaps Jew, Christian and Mohammedan might be induced to unite on the new Seventh-day as a universal Sabbath.

S. Solis Cohen

SCIENTIFIC BOOKS

HAECKEL'S EVOLUTION OF MAN

Since the publication in 1883 of an English translation of the third edition of Haeckel's "Evolution of Man," there has been no English republication of a later edition until now. The third edition was a revision, in 1876, of the first; the second was only a reprinting of the unchanged original. Since 1876 some things have been discovered about the evolution of man, and many things have been said about Haeckel's conception and treatment of the subject. In addition, two more German editions of Haeckel's book, the fourth and fifth, have been published. Of these the fifth is a very thorough revision, involving some enlargement and bringing the matter of the book into line with present-day knowledge.

Perhaps this last sentence is not a very happy one. Haeckel's particular evolutionary interpretation of present-day knowledge of human structure, physiology and development may not be held by all biologists to be a true bringing of this knowledge into line. "Der Haeckelismus in der Zoologie" is a subject that will not down wherever biologists come together. And its discussion usually leads to a going apart.

Biologists are likely to be of two minds concerning the advisability of putting Haeckel's "Evolution of Man" into the hands of the lay reader as a guide and counselor on this most important of evolution subjects. Haeckel is such a proselytizer, such a scoffer and fighter of those who differ with him, that plain, unadorned statement of facts and description of things as they are can not be looked for in his books. Or, if looked for, can not be found. But this very eagerness to convince; this hoisting of a thesis, this fight for Haeckelian phylogeny and Haeckelian monism, all make for interest and life in his writings.

The present new English[1] translation of the fifth German edition of "The Evolution of Man" is by Joseph McCabe, who does it well. He is the same writer who translated into English those two very successful, popular books of Haeckel, "The Riddle of the Universe" and "The Wonders of Life." These two little books have had such an extraordinary circulation (in most of the languages of the civilized earth) that "The Evolution of Man," much larger though it is—it is in two illustrated volumes of about 350 pages each—and more detailed and technical, will nevertheless undoubtedly be welcomed by a considerable public. It will certainly give this public a much better opportunity than do the smaller books to judge for itself of the soundness of the conclusions of biology touching the evolution of man. For despite possible criticism of details, and the dogmatism of the whole, it is a book of facts; a compendium of description of the course of human ontogeny and mammalian phylogeny, and of the evolution of animal structure and functions. It is provided with index and glossary, is generously illustrated, and admirably printed and bound.

V. L. K.

Stanford University, Cal.

Catalogue of the Hemiptera (Heteroptera), with biological and anatomical references, lists of food plants and parasites, etc. Prefaced by a discussion on Nomenclature and an analytical table of families. By G. W. Kirkaldy. Vol. 1, Cimicidæ. Berlin, published by Felix L. Dames. 1909.

While primarily a catalogue, this work is something more in that it includes a discussion of the rules of nomenclature and their interpretation as applied to the adoption of

[1] Haeckel, E., "The Evolution of Man," translated by Joseph McCabe, 2 vols., illustrated, 1910, G. P. Putnam's Sons, New York.

generic and specific names used in the catalogue.

The author adopts some quite radical changes in the use of names in some of the groups, some of them doubtless justified by international rules, but in some cases as a result of particular interpretation in which he will probably not be followed by all entomologists.

One of the cases where a strict adhesion to his interpretation of the code results in a defeat of an author's purpose shows in the retention of *Handhirschiella* where the author, Montandon, intending to honor the eminent Dr. Handlirsch dedicated a genus to him. By a typographical error it appeared first misspelled, but was immediately afterward corrected by the author.

Fortunately, it appears that in a large majority of cases for our American species, and so far as this volume carries, the names have suffered but little in the process and we may still know most of our species by the names which have been familiar for the past quarter century.

One must recognize the immense labor involved in the making of such a catalogue and even if unwilling to accept all the changes of form admire the persistence that has enabled the author to bring out so full a work. It is especially unfortunate that the death of the gifted author should interrupt the unfinished parts, and it is sincerely to be hoped that some one equally well equipped may be found to carry it to completion.

The make up of the volume is excellent and so far as my examination has disclosed it is very commendably free from typographical errors, a point which is perhaps more remarkable when we understand that printer and author were at such distance from each other as Berlin and Honolulu.

Excepting the omission of locality reference for *Amaurochrous cinctipes* Say (a common American species) no serious omission has been noticed.

The inclusion of a number of tabular summaries of distribution is very serviceable in showing at a glance the habitat of each group. Another good feature is the inclusion of fossil as well as living species.

Herbert Osborn

A Synonymic Catalogue of Orthoptera. By W. F. Kirby. London, 8vo. Vol. I. (1904). (Nonsaltatorial forms), x + 501 pages; Vol. II. (1906). (Saltatorial forms, Part I., Achetidæ and Phasgonuridæ), viii + 562 pages; Vol. III. (1910). (Saltatorial forms, Part II., Locustidæ or Acridiidæ), vii + 674 pages.

The third and last volume of this general catalogue appeared some weeks ago. The three volumes comprise one of the most complete catalogues of an entire order of insects ever published and no catalogue of the Orthoptera covers the entire field as does this one. The three volumes, aggregating nearly 1,800 pages, represent an enormous amount of bibliographical research, and during their preparation the author went critically over the entire field, correcting nomenclature, revising many genera and rectifying synonymy. The resulting catalogue is a model of its kind. The number of genera entered, not including synonyms, are as follows, given by families as used in the catalogue:

Forficulidæ	52	Phasmidæ	195
Hemimeridæ	1	Phasgonuridæ	689
Blattidæ	197	Locustidæ	826
Mantidæ	209	Achetidæ	154
Total			2,323

Some additions are entered in the appendix to Volume III., and since the catalogue was published many genera have been established, especially in the Phasmidæ. There are now nearly or quite 2,500 genera in use in the entire order.

While little but favorable comment can be passed upon this valuable catalogue it still contains, in the opinion of the reviewer, a few more or less serious faults. The first of these in importance is the method of geneotype citation, which is done by referring to the number under which the type species occurs under the genus. Two features about this

method are bad: (1) One can not tell in many cases if it is the valid species under the number cited which is the type or if it is one of often several synonyms entered under that number. (2) Clerical error is almost inevitable when this method is employed in a large catalogue like the one now under review. Thus in a goodly number of cases the geneotype cited by Mr. Kirby is obviously wrong, often being a species but recently described or not one originally included. Such errors are evidently due to adding a species to the genus, or taking one away, after citing the type. An indication of the method by which the geneotype was determined in each case would have been a valuable addition to the catalogue.

The differentiation of actual species in synonymy from mere misidentifications would have materially enhanced the value of the catalogue. The use of a "†" to distinguish misidentifications is a method to be commended.

Relative to the general construction of the catalogue it seems that the author is prone to recognize as valid too many genera and species, as well as subfamilies, being rather over conservative as to the suppression of names. Here and there, also, occur nomenclatorial matters about which not all will agree. Thus the choosing of Achetidæ for the Gryllidæ and Phasgonuridæ, rather than Tettigonidæ, for the long-horned grasshoppers are actions seemingly unjustified.

The omission of genera and species from this catalogue, while aggregating quite a goodly number, are not many when the vast field covered by it is considered. No catalogue of even a tithe the volume of this one is free from errors and omissions and thus the leaving out of a few genera and species is not a matter deserving adverse criticism. As a whole these three volumes form a creditable and lasting monument to their eminent author.

The undersigned has critically reviewed those portions of the first two volumes pertaining to the United States forms.[1] It is his intention to review this third volume in a like manner in the near future.

A. N. Caudell

U. S. National Museum

[1] *Proc. Ent. Soc. Wash.*, Vol. VII., pp. 84–88, 1905; *Can. Ent.*, Vol. XL., pp. 287–292, 1907.

SCIENTIFIC JOURNALS AND ARTICLES

Beginning in January next there will be published bimonthly a *Journal of Animal Behavior* and at irregular intervals an *Animal Behavior Monograph Series.* The journal will accept for publication field studies of the habits, instincts, social relations, etc., of animals, as well as laboratory studies of animal behavior or animal psychology. It is hoped that the organ may serve to bring into more sympathetic and mutually helpful relations the "naturalists" and the "experimentalists" of America, that it may encourage the publication of many carefully made naturalistic observations which at present are not published, and that it may present to a wide circle of nature-loving readers accurate accounts of the lives of animals.

Reviews of especially important contributions within its field will be published as they are prepared, and, in addition, a number especially devoted to reviews, digests, and a bibliography of the contributions to animal behavior and animal psychology for the year will be published annually.

The journal is under the editorial direction and management of:

I. Madison Bentley, assistant professor of psychology, Cornell University.

Harvey A. Carr, assistant professor of psychology, The University of Chicago.

Samuel J. Holmes, assistant professor of zoology, The University of Wisconsin.

Herbert S. Jennings, professor of experimental zoology, The Johns Hopkins University.

Edward L. Thorndike, professor of educational psychology, The Teachers College of Columbia University.

Margaret F. Washburn, professor of psychology, Vassar College.

John B. Watson, professor of experimental and comparative psychology, The Johns Hopkins University.

William M. Wheeler, professor of economic entomology, Harvard University.

Robert M. Yerkes, assistant professor of comparative psychology, Harvard University.

The Animal Behavior Monograph Series will be published in connection with the *Journal* as a provision for papers which are too lengthy, or, for other reasons, too costly to be accepted by the *Journal*. The monographs of this series will appear at irregular intervals and will be grouped in volumes of approximately 450 pages.

The Journal of Animal Behavior and *The Animal Behavior Monograph* Series will be published for the editorial board by Henry Holt and Company, New York. Manuscripts for the *Journal* may be sent to the managing editor, Professor Robert M. Yerkes, Emerson Hall, Cambridge, Massachusetts, or to any other member of the editorial board. Manuscripts for the Monograph Series should be sent to the editor, Professor John B. Watson, Johns Hopkins University, Baltimore, Maryland, from whom information may be obtained concerning terms of publication. Books and other matter for review in the *Journal* should be sent to the editor of reviews, Professor Margaret F. Washburn, Vassar College, Poughkeepsie, New York.

The concluding (October) number of volume 11 of the *Transactions of the American Mathematical Society* contains the following papers:

Virgil Snyder: "Conjugate line congruences contained in a bundle of quadric surfaces."

Jacob Westlund: "On the fundamental number of the algebraic number field $k(p\sqrt{m})$."

G. C. Evans: "Volterra's integral equation of the second kind, with discontinuous kernel."

H. Beck: "Ein Seitenstück zur Moebius'schen Geometrie der Kreisverwandtschaften."

Louis Ingold: "Vector interpretation of symbolic differential parameters."

L. P. Eisenhart: "Surfaces with isothermal representation of their lines of curvature and the transformations (second memoir)."

G. E. Wahlin: "On the base of a relative number field, with an application to the composition of fields."

L. M. Hoskins: "The strain of a non-gravitating sphere of variable density."

Also Table of Contents of Volume 11.

The opening (October) number of volume 17 of the *Bulletin of the American Mathematical Society* contains: "Note on implicit functions defined by two equations when the functional determinant vanishes," by W. R. Longley; "Sturm's method of integrating $dx/\sqrt{X} + dy/\sqrt{Y}$," by F. H. Safford; "A property of a special linear substitution," by F. R. Sharpe; "On the factorization of integral functions with p-adic coefficients," by L. E. Dickson; Review of Hensel's Theorie der algebraischen Zahlen, by L. E. Dickson; Shorter Notices: Lehmer's Factor Table for the First Ten Millions, by L. E. Dickson; Staude's Analytische Geometrie des Punktepaares, des Kegelschnittes und der Fläche zweiter Ordnung, by D. D. Leib; Dette's Analytische Geometrie der Kegelschnitte, by D. D. Leib; Lebon's Henri Poincaré, Biographie, Bibliographie, by J. W. Young; André's Notations mathématiques, by G. A. Miller; Hancock's Applied Mechanics for Engineers, by E. W. Ponzer; "Notes"; "New Publications."

The November number of the *Bulletin* contains: Report of the summer meeting of the society, by F. N. Cole; Report on "The preparation of college and university instructors in mathematics," by the American sub-committee of the International Commission on the Teaching of Mathematics; Review of works on vector analysis (Coffin, Gans, Ignatowsky), by H. B. Phillips; "Notes"; "New Publications."

A SECOND EARLY NOTE ON THE TRANSMISSION OF YAWS BY FLIES

In Science for January 7, 1910, I communicated a note giving observations made by Edward Bancroft in 1769 on the transmission by flies of this malignant tropical skin disease. Recently in looking over Henry Koster's "Travels in Brazil in the Years from 1809 to 1815," published in Philadelphia in 1817, I found the following more specific statement as to the means of transmission of this loathsome disease. In Vol. II.,

pages 235 and 236, after giving a description of the disease, he says:

This horrible disorder [the yaws] is contracted by inhabiting the same room with the patient, and by inoculation; this is effected by means of a small fly, from which every precaution is oftentimes of no avail. Great numbers of the insects of this species appear in the morning, but they are not so much seen when the sun is powerful. If one of them chances to settle upon the corner of the eye or mouth, or upon the most trifling scratch, it is enough to inoculate the *bobas*, if the insect comes from a person who labors under the disease.

It will be noted that, while Koster is not able to give the specific name of the fly, he definitely declares it to be a certain fly with well marked characters. It may be well to add that the disease called "bobas" throughout Brazil, is identified by Koster himself as identical with the "yaws" prevalent in Venezuela and the Guianas.

For the loan of the book from which this note is taken, I am indebted to the courtesy of Mr. E. C. Richardson, librarian of Princeton University.

E. W. Gudger

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Greensboro, N. C.

SPECIAL ARTICLES

A FURTHER STATISTICAL STUDY OF AMERICAN MEN OF SCIENCE

The advancement of science and the improvement of the conditions under which scientific work is done are of such vast importance for society that even the most modest attempt to introduce scientific method into the study of these conditions has some value. It is truly both exhilarating and appalling to face the opportunities and responsibilities of science and of scientific men. The applications of science have quadrupled the wealth which each individual produces and have doubled the length of human life. In many cases the gain has been greater than this. In transporting freight or printing a newspaper, the products of each man's labor have been multiplied a hundredfold; in equal measure the danger from smallpox, cholera and the plague has been diminished.

As intercommunication increases between the nations, bringing them all within the circle of our civilization, and as the total population of the earth grows, the number of scientific advances becomes continually larger and the value of each of ever greater magnitude. It is thus an economic law that the means of subsistence tend to increase more rapidly than the population.[1] When the applications of electricity increase the efficiency of each individual on the average by twenty per cent.—as may now be the case in civilized countries—the economic value would be in the neighborhood of twenty billion dollars a year. In comparison with a sum so inconceivable, the cost of science since the days of Faraday and Henry is altogether insignificant. In the United States at present there are scarcely more than a thousand men engaged in serious research work, and they do not on the average devote more than half their time to it. Throughout the world there may be seven to ten times as many. The investigations of these men may cost a total of $20,000,000 a year, perhaps one thousandth of what may be gained by the applications of electricity, or one hundredth of what is saved by the use of the phosphorus match.

But man does not live alone by the applications of electricity and the use of the phosphorus match. Science has given us a new heaven as well as a new earth, for it has checked not only poverty and disease, but also superstition, ignorance and unreason. It has done away with slavery and with the need of child labor; it has made excessive manual labor by women or by men unnecessary. By

[1] This inversion of the law of Malthus, to which the writer has called attention on several occasions (*e. g.*, Science, December 18, 1896) has recently been given a most interesting expression by Professor T. H. Norton (*The Popular Science Monthly*, September, 1910). Both the number and the value of scientific advances being directly proportional to the total population, the means of subsistence tend to increase as the square of the population.

giving the possibility of leisure and education to all it has made democracy possible. Finally science has not only given us leisure, but also the means to occupy that leisure in a worthy manner; its intellectual and emotional appeal is almost equal to the art and religion which were so much earlier in their origin.

Science has been more successful in the production of wealth than in its distribution and use, and it has been more effective in its control of the material world than of human conduct; but this is a natural result of necessary lines of development. The methods which have slowly extended from physics and chemistry to the more complicated phenomena of biology will give us sciences of psychology, sociology and anthropology and applications of these sciences commensurate with their dominant importance. Science has, indeed, already profoundly altered not only the material conditions of life but also social relations and mental contents and attitudes. The conditions of heredity and circumstance which determine the whole course of life are subject to its control. We need only to obtain the knowledge and to apply it. If an improvement of ten per cent. in the cereal crop will yield a billion dollars a year, in what terms of money should an increase of ten per cent. in the annual output of science be stated?

The application of scientific methods to the advancement of science is in one sense the beginning of science and in another one of its latest undertakings. We are at present almost wantonly ignorant and careless in regard to the conditions which favor or hinder scientific work. We do not know whether progress is in the main due to a large number of faithful workers or to the genius of a few. We do not know to what extent it may be possible to advance science by increasing the number of scientific positions or how far such an increase might be expected to add to the number of men of genius. We do not know to what extent increased salaries, better facilities and greater leisure would favor the quantity and quality of our work. We do not know to what extent non-rational sanctions, such as reputation, offices, titles, degrees, prizes, membership in exclusive societies and the like are effective. We do not know whether it is wise to combine teaching with research or applied with pure science. We do not know whether it is better for the professor and investigator to have a moderate salary, a life position and a pension, or to engage in severe competition for large prizes; whether obedience and discipline should be prescribed or the largest individual liberty allowed. We know but little as to the kind of education, methods of work and mode of life, which are most favorable to scientific productivity. In the face of endless problems of this character we are as empirical in our methods as the doctor of physic a hundred years ago or the agricultural laborer to-day. It is surely time for scientific men to apply scientific methods to determine the circumstances that promote or hinder the advancement of science. We should begin where and when we can; even though the results of the first efforts may appear somewhat trivial, we may proceed in the confident belief that in the end the advancement of science will become an applied science.

In a series of three articles published in the numbers of SCIENCE for November 23 and 30 and December 7, 1906, the writer described the methods which he used to select a group of a thousand leading American men of science, the application of these methods to the measurement of scientific merit, and the origin and distribution of the group. About seven years having elapsed since the selection of the group treated in these articles and a second edition of the "Biographical Directory of American Men of Science" being in preparation, it seemed desirable to repeat the process of determining the thousand leading scientific men in the United States. It is worth while to learn what changes have taken place in the composition of this group and in the distribution of the scientific men among various institutions and in different parts of the country. A list of scientific men as nearly

contemporary as might be was also wanted for some further studies of the conditions of heredity and environment which are favorable to scientific productivity.

The methods used to select the group of a thousand leading men of science were substantially the same as before and need not be redescribed in detail. The scientific men were distributed among twelve sciences as previously. It was intended that the number in each science should be proportional to the total number of investigators in that science, and it was as nearly so as is needful for the purpose in view. The distribution was as follows: Chemistry, 175; physics, 150; zoology, 150; botany, 100; geology, 100; mathematics, 80; pathology, 60; astronomy, 50; psychology, 50; physiology, 40; anatomy, 25; anthropology, 20.

In each science twice as many names were selected and written on slips with the addresses and positions. The ten men of science who stood at the head of the list in each science in the previous arrangement were asked to arrange the names in that science in the order of merit. The memorandum of instructions read: "It is obvious that such an order can be only approximate, and for the objects in view an approximation is all that is needed. The judgments are possible, because they are as a matter of fact made in elections to a society of limited membership, in filling chairs at a university, etc. By merit is understood contributions to the advancement of science, primarily by research, but teaching, administration, editing, the compilation of text-books, etc., should be considered. The different factors that make a man efficient in advancing science must be roughly balanced."

There were thus at hand in each science ten arrangements of those known to have done research work in the order of the value of their work, as estimated by those having expert knowledge. The ten positions assigned to each individual were then averaged, and the workers in each science were arranged in order. The lists for the twelve sciences were interpolated to form a combined list of a thousand scientific men. A second group in each science and a second group of a thousand scientific men were in like manner obtained. This was not done before, and the second thousand has less validity than the first thousand. It has, however, a certain interest for purposes of comparison.

The average of ten judgments is not necessarily more correct than any one of these judgments; the conditions are similar to observations in the exact sciences. One good observation may have more validity than the average of a number of observations made under less favorable conditions. But if ten scientific men concerning whose competence it is not possible to discriminate in advance make a judgment, we may take the average as the most probable value. If we had but a single judgment we should not know its validity, but with ten judgments the probable error can be calculated. These probable errors tell us not only the limits within which the place of an individual in the series is likely to be correct, but also measure the differences between the individuals.

This method of converting a qualitative series into a series of quantitative differences may be illustrated by the case in which it was used by the writer for the first time.[2] Some two hundred shades of gray were made, giving approximately equal differences in illumination between white and black. In such a series the grays toward the white end appear more alike than those toward the black end, and two adjacent grays are indistinguishable. Psychologically it is a qualitative series. If now the grays are arranged in the order of brightness a number of times by the same or different observers and the average position in the series of each gray is determined, the mean variation is inversely proportional to the psychological differences between the grays. There is thus determined the quantitative differences in the perception and its relation to the physical differences between the lights. The same methods have been used in the Co-

[2] "The Time of Perception as a Measure of Differences in Intensity," *Philos. Studien*, **19**: 63–68, 1902.

lumbia laboratory of psychology to measure the validity of beliefs, the beauty of pictures, differences in traits of character, literary skill and efficiency in various performances.

The method used enables us to measure not only differences in scientific merit, but also the accuracy of judgment of those who make the arrangements. It would be possible to determine whether those more eminent have the more accurate judgments, at what age the individuals are most competent and the like. As a matter of fact, the judgments in the present case were made by those most eminent in each science who were willing to undertake the task. Of the ten in each science who were placed at the head of the list in the previous study,[3] or 120 in all, 80 consented to undertake the arrangement, and of these 68 sent in valid lists. Others in the order of eminence were then asked until ten lists were obtained in each science. This study has thus only been made possible by the cooperation of those whose time is of much value. My personal obligations to them are very great.

The names of those selected for arrangement included all who were known to have done research work of any consequence, and those who arranged them were asked to add any who had been omitted. Some names deserving consideration were doubtless neglected and consequently would not find a place in the first or second thousands as ultimately selected. Each of those included in the first group is probably among the leading thousand scientific men in the United States, but there are a few others who belong to this group though not included. It might be a service to science to print the list of our thousand leading scientific men in the order of merit together with the probable error of each position, but it would require courage to do this, and perhaps it would not be possible to obtain the arrangement if it were to be made known. In the "Biographical Directory of American Men of Science" those are indicated by stars who belong either to the group as selected seven years ago or as selected now. Those who have won a place in the group can be identified by a comparison of the two editions of the book. Those who have lost their places in the group can not be known.

[3] Six were not asked owing to their illness or absence from the country. These conditions also account for a number of those who did not reply to the letter or did not consent to make the arrangement.

The arrangements of each of the two lists extended over a period of some months. The first list may be dated as approximately of January 1, 1903, and the second list as approximately of January 1, 1910. The distributions given in the previous paper refer approximately to January 1, 1906, the residences and positions used being those given in the first edition of the directory. For the present list, the residences and positions are those of January 1, 1910. It would be better if the arrangement of the first list and the distributions referred to the same date, but it was not possible to work up the data more promptly, as the writer was able to attend to the compilation of the directory and the statistics only during the summer months. In collecting and compiling the data he has had the very valuable assistance of Professor V. A. C. Henmon, of the University of Wisconsin, and of Mr. E. K. Strong, Jr., fellow in psychology in Columbia University.

Those included in the list of 1903 who died prior to 1910 number 58. It is a roll of honor which may be given here:

1903 (in part)

Bolton, Henry Carrington	*Chemistry*
Rhoads, Edward	*Physics*

1904

Beecher, Charles E.	*Geology*
Drown, Thomas Messenger	*Chemistry*
Hatcher, John Bell	*Geology*
Herrick, Clarence Luther	*Zoology*
Palmer, Arthur William	*Chemistry*
de Schweinitz, Emil Alexander	*Chemistry*

1905

Brace, DeWitt Bristol	*Physics*
Eldridge, George Homans	*Geology*
Ellis, Job Bicknell	*Botany*
Ewell, Ervin E.	*Chemistry*

MATTHEWS, WASHINGTON	*Anthropology*
PACKARD, ALPHEUS SPRING	*Zoology*
PRESCOTT, ALBERT BENJAMIN	*Chemistry*
WARDER, ROBERT BOWNE	*Chemistry*
WOOD, EDWARD STICKNEY	*Chemistry*

1906

LANGLEY, SAMUEL PIERPONT	*Physics*
MACCALLUM, JOHN BRUCE	*Anatomy*
MILLER, EDMUND HOWD	*Chemistry*
MORGAN, ANDREW PRICE	*Botany*
PAULMIER, FREDERICK CLARK	*Zoology*
PEIRCE, JAMES MILLS	*Mathematics*
PENFIELD, SAMUEL LEWIS	*Mineralogy*
RUSSELL, ISRAEL COOK	*Geology*
SHALER, NATHANIEL SOUTHGATE	*Geology*

1907

ATWATER, WILBUR OLIN	*Chemistry*
CALDWELL, GEORGE CHAPMAN	*Chemistry*
CARROLL, JAMES	*Pathology*
CLARK, GAYLORD PARSONS	*Physiology*
GARDINER, EDWARD GARDINER	*Zoology*
GATSCHET, ALBERT SAMUEL	*Anthropology*
HEILPRIN, ANGELO	*Geology*
NEWELL, WILLIAM WELLS	*Anthropology*
REES, JOHN KROM	*Astronomy*
SAFFORD, JAMES MERRILL	*Geology*

1908

ANTHONY, WILLIAM ARNOLD	*Physics*
ASHMEAD, WILLIAM HARRIS	*Zoology*
AUSTEN, PETER TOWNSEND	*Chemistry*
BROOKS, WILLIAM KEITH	*Zoology*
DAVENPORT, GEORGE EDWARD	*Botany*
GIBBS, OLIVER WOLCOTT	*Chemistry*
JOHNSON, SAMUEL WILLIAM	*Chemistry*
KELLERMAN, WILLIAM ASHBROOK	*Botany*
LEE, LESLIE ALEXANDER	*Zoology*
MASCHKE, HEINRICH	*Mathematics*
MASON, OTIS TUFTON	*Anthropology*
SNOW, FRANCIS HUNTINGTON	*Zoology*
UNDERWOOD, LUCIEN MARCUS	*Botany*
WHITEHEAD, CABELL	*Chemistry*
YOUNG, CHARLES AUGUSTUS	*Astronomy*

1909

DUDLEY, CHARLES BENJAMIN	*Chemistry*
HARRIS, WILLIAM TORREY	*Psychology*
HOUGH, GEORGE WASHINGTON	*Astronomy*
NEWCOMB, SIMON	*Astronomy*
STEARNS, ROBERT EDWARDS CARTER	*Zoology*
STRINGHAM, WASHINGTON IRVING	*Mathematics*
TUFTS, FRANK LEO	*Physics*

The death rates for the six past years have been 6, 9, 9, 10, 15 and 7, on the average 9.3 per thousand. The rates for those under and over fifty, respectively, were approximately 3 and 21. The number of cases is too small for reliable data, but they show a youthful scientific population. In Great Britain there are annually elected into the Royal Society fifteen new fellows, and a membership of about 450 is maintained. The death rate is consequently over 30. It has been claimed that scientific men live longer than the average, and they probably do, but this can not be proved from the age at which they die, unless the age at which they become scientific men is known. If, however, we assume that scientific men live to the average age, we can from the age at which they die determine the age at which they become scientific men or reach a given degree of eminence.

In addition to those who died, there were removed from the thousand nine foreign men of science, who are no longer residents of the United States, and one other man whose address is unknown. There would thus be 68 vacancies on the list of 1910 to be filled by new men. In the order of the list, there is a probable error which increases from about 10 places at the top to about 100 places at the bottom. Consequently if the same scientific men were rearranged under the same conditions, each of those in the last hundred would be subject to a chance of one in four or more of being dropped from the list. In a general way 37 from the last hundred, 15 from the next to last, or ninth hundred, five from the eighth hundred and one from the seventh hundred—58 in all—might be expected to drop from the thousand as a result of rearrangement.

Apart from the 68 who died or were removed and the 58 changes due to a chance variation, there were 143 on the list of 1903 who failed to find a place on the list of 1910. These are the scientific men who did not maintain their positions in competition with their colleagues. There were 269 who attained a place on the list of 1910 for the first time. It

TABLE I. BIRTHPLACE AND RESIDENCE OF THOSE ADDED TO AND DROPPED FROM THE LIST

	Birthplace.							Residence.						
	Men Added.			Men Dropped.				Men Added.			Men Dropped.			
	New.	Old.	Total.	Out.	Dead.	Gone.	Total.	New.	Old.	Total.	Out.	Dead.	Gone.	Total.
North Atlantic.														
Maine	5	1	**6**	8	2	0	**10**	1	1	**2**	1	1	0	**2**
New Hampshire	3	0	**3**	5	1	0	**6**	1	0	**1**	1	0	0	**1**
Vermont	2	1	**3**	3	1	0	**4**	0	0	**0**	1	0	0	**1**
Massachusetts	24	3	**27**	21	9	0	**30**	40	3	**43**	23	6	0	**29**
Rhode Island	3	1	**4**	0	1	0	**1**	2	1	**3**	1	2	0	**3**
Connecticut	6	0	**6**	5	2	0	**7**	14	2	**16**	4	4	0	**8**
New York	31	5	**36**	43	18	0	**61**	31	7	**38**	49	9	2	**60**
New Jersey	3	1	**4**	6	1	0	**7**	5	0	**5**	6	2	0	**8**
Pennsylvania	13	1	**14**	14	4	0	**18**	10	3	**13**	19	5	1	**25**
South Atlantic.														
Delaware	0	0	**0**	1	0	0	**1**	0	0	**0**	1	0	0	**1**
Maryland	2	0	**2**	4	0	0	**4**	11	2	**13**	6	2	0	**8**
Dist. of Col.	1	0	**1**	3	0	0	**3**	23	3	**26**	24	11	1	**36**
Virginia	7	0	**7**	5	1	0	**6**	0	0	**0**	1	0	0	**1**
West Virginia	2	0	**2**	0	0	0	**0**	1	0	**1**	0	0	0	**0**
North Carolina	0	0	**0**	0	1	0	**1**	3	0	**3**	1	0	0	**1**
South Carolina	3	0	**3**	1	0	0	**1**	0	0	**0**	0	0	0	**0**
Georgia	1	0	**1**	0	0	0	**0**	0	0	**0**	0	1	0	**1**
Florida	1	0	**1**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
South Central.														
Kentucky	2	0	**2**	2	1	0	**3**	0	0	**0**	2	0	0	**2**
Tennessee	2	0	**2**	2	0	0	**2**	0	0	**0**	2	0	0	**2**
Alabama	1	1	**2**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
Mississippi	1	0	**1**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
Louisiana	0	0	**0**	0	0	0	**0**	1	0	**1**	1	0	0	**1**
Texas	2	0	**2**	1	0	0	**1**	2	0	**2**	2	1	0	**3**
Oklahoma	0	0	**0**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
Arkansas	0	0	**0**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
North Central.														
Ohio	19	4	**23**	15	6	0	**21**	9	1	**10**	6	2	0	**8**
Indiana	11	1	**12**	3	0	0	**3**	5	0	**5**	6	0	0	**6**
Illinois	10	4	**14**	8	1	0	**9**	25	3	**28**	15	3	0	**18**
Michigan	17	0	**17**	8	1	0	**9**	5	0	**5**	2	2	3	**7**
Wisconsin	11	0	**11**	10	0	0	**10**	12	1	**13**	0	0	0	**0**
Minnesota	5	0	**5**	1	1	0	**2**	2	1	**3**	4	0	0	**4**
Iowa	8	1	**9**	3	0	0	**3**	1	0	**1**	3	0	0	**3**
Missouri	5	0	**5**	4	0	0	**4**	6	0	**6**	1	0	0	**1**
North Dakota	0	0	**0**	0	0	0	**0**	0	0	**0**	1	0	0	**1**
South Dakota	0	0	**0**	0	0	0	**0**	1	0	**1**	0	0	0	**0**
Nebraska	1	0	**1**	1	0	0	**1**	4	0	**4**	3	1	0	**4**
Kansas	0	0	**0**	1	0	0	**1**	2	0	**2**	1	1	0	**2**
Western.														
Montana	0	0	**0**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
Wyoming	0	0	**0**	0	0	0	**0**	0	0	**0**	1	0	0	**1**
Colorado	0	0	**0**	1	0	0	**1**	2	0	**2**	1	0	0	**1**
New Mexico	0	0	**0**	0	0	0	**0**	0	0	**0**	0	1	0	**1**
Arizona	0	0	**0**	0	0	0	**0**	1	0	**1**	1	0	0	**1**
Utah	0	0	**0**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
Nevada	0	0	**0**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
Idaho	0	0	**0**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
Washington	0	0	**0**	0	0	0	**0**	0	0	**0**	0	0	0	**0**
Oregon	1	0	**1**	0	0	0	**0**	1	0	**1**	0	0	0	
California	4	0	**4**	2	0	0	**2**	14	1	**15**	10	3	0	**13**
Alaska	0	0	**0**	0	0	0	**0**	0	0	**0**	0	1	0	**1**
Hawaii	0	1	**1**	0	0	0	**0**	0	1	**1**	0	0	0	**0**
Philippines	1	0	**1**	0	0	0	**0**	2	0	**2**	0	0	0	**0**
Panama	0	0	**0**	0	0	0	**0**	0	1	**1**	0	0	0	**0**

	Birthplace.							Residence.						
	Men Added.			Men Dropped.				Men Added.			Men Dropped.			
	New.	Old.	Total.	Out.	Dead.	Gone.	Total.	New.	Old.	Total.	Out.	Dead.	Gone.	Total.
Canada	8	1	9	6	2	5	13	0	0	0	0	0	1	1
England	0	0	0	6	2	1	9	0	0	0	0	0	1	1
Scotland	3	1	4	2	0	1	3	0	0	0	0	0	0	0
Wales	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Ireland	1	0	1	0	1	0	1	0	0	0	0	0	0	0
Germany	5	1	6	1	1	0	2	0	0	0	1	0	0	1
Switzerland	0	0	0	0	1	1	2	1	0	1	0	0	1	1
Belgium	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Austria	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Russia	3	0	3	2	0	0	2	0	0	0	0	0	0	0
Sweden	1	1	2	0	0	0	0	0	0	0	0	0	0	0
Norway	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Japan	1	1	2	0	0	0	0	0	0	0	0	0	0	0
China	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Unknown	7	0	7	1	0	1	2	0	0	0	0	0	0	0
Total	238	31	269	201	58	10	269	238	31	269	201	58	10	269

seems best to remove from this group those who would probably have been given a place on the list of 1903, but were not considered at the time. They number 31, of whom only one is a foreigner who came to this country in the period of seven years.

There were 126 foreign-born men of science on the list of 1903. While the majority came to this country before attaining scientific reputation, a large number were called from Canada, Great Britain, Germany and other countries to fill positions in our universities, of whom seven were among our leading hundred men of science. The members of this group have added greatly to the scientific strength of the country, not only by the research that they have accomplished, but also because they have brought familiarity with the educational methods of other nations, and high ideals of scholarship and of the dignity of the career of the scientific man and university professor. It is surprising and truly most unfortunate that while nine leading foreign men of science have returned to their native countries during the past seven years, only one has come to America—one scientific man among seven million immigrants. There is no way by which the abundant wealth of the country could be used to greater advantage than by bringing to it men of promise and men of distinction.

We have then a group of 238 scientific men, who in the course of seven years have attained a place among the leading thousand, and a group of 201 who have lost their places. These two groups deserve careful consideration. Together with the other groups added to and taken from the list, they are distributed geographically in respect to birthplace and residence, as shown in Table I.

Massachusetts still retains its leadership in the production of scientific men, but it has lost ground in the course of the past seven years, while the north central states have gained. In the list of 1903, the birth rate of scientific men was at the rate per million population of about 50 in Maine, New Hampshire and Vermont, 109 in Massachusetts and 87 in Connecticut. If for purposes of comparison we increase the 238 new men to a thousand and again by 22.6 per cent. to allow for the increase in population of the country between 1860 and 1870, the corresponding figures (referred to the census of 1870) would be: Maine, New Hampshire and Vermont, about 40; Massachusetts 85, Connecticut 57. By the same method of comparison the figures have decreased in the central Atlantic states, as follows:

New York	47 to 36
New Jersey	42 to 17
Pennsylvania	23 to 19
Maryland	38 to 13

On the other hand, the north central states show an increase, the figures being:

Ohio	32 to 35
Indiana	21 to 34
Illinois	24 to 20
Michigan	36 to 74
Wisconsin	45 to 54
Minnesota	23 to 59
Iowa	30 to 34
Missouri	12 to 15

The cases are too few to give exact quantitative data, but a comparison of the north Atlantic and the north central states is significant. The former have lost seriously in their production of scientific men, while the latter have gained in every case except Illinois. Michigan rivals Massachusetts and surpasses every other state. New York on the list of 1903 surpassed every north central state, whereas the new men on the list of 1910 equal or exceed those from New York in six of the eight north central states. The big cities—New York, Philadelphia, Baltimore and Chicago—have lost ground. The birth rate per million inhabitants on the basis of 1,000 scientific men has fallen as follows:

New York	71 to 33
Philadelphia	49 to 23
Baltimore	94 to 19
Chicago	73 to 17

These cities, in spite of their vast wealth and great universities, and the fact that the ambitious and successful are drawn to them, are failing to produce scientific men. For the thousand of 1903, it was found that the urban birth rate was 50 and the rural birth rate 24. The 238 new men are too few to give reliable figures, but it seems that the cities are failing to produce scientific men, and presumably other men of intellectual performance, to an extent that is ominous.

Nebraska, Kansas and the states west to the Pacific have not improved, as the writer would have anticipated from the students in psychology who have worked with him. Probably the gain in the north central states is now extending westward and will show later. The southern states, though still lamentably deficient in their productivity of scientific men, have improved decidedly. They have produced 22 scientific men among the 238, as compared before with 48 among the 1,000.

Among the 238 men who have obtained a place on the list, 23 were born abroad, as compared with 126 among 1,000 on the list of 1903. The percentage from Canada and Germany is the same and it is larger from Russia. In the case of other countries the numbers are too small to be significant, except England, from which country there were 25 in the list of 1903 and not a single one among the new men on the list of 1910. As has been already noted, only one foreigner has been called to this country of such scientific standing that he would have clearly deserved a place on the list of 1903. Nearly all the foreign-born scientific men acquired their scientific reputation after coming to this country. Fifteen of the 23 were wholly or partly educated in the United States.

A comparison of the first and eighth columns in the table will show which states have retained fewer men than they have produced and which have drawn on other states. Thus the three rural New England states have produced 10 men and have retained but two, while Massachusetts has produced 24 and has at present 40. New York has exactly as many as it has produced, 31, though of course the individuals are not all the same. The District of Columbia must depend on other parts of the country for its scientific men; the number it has obtained, 23, is just the number born abroad, so the balance is even among the states. Illinois has called men from other states, Wisconsin and Missouri have maintained nearly an even balance, while the other central states have lost their men—Michigan 12 of 17, Ohio 10 of 19, Indiana 6 of 11 and Iowa 7 of 8. It seems a pity that these wealthy states can not retain the men they

produce or make an equal exchange with other states. The western states have tended to add to the number of men they have produced, thus California has produced 4 and acquired 10 more. The southern states have lost their men. Their increasing wealth has led to greater productivity, but they have not yet learned the importance of retaining and securing scientific men.

Reviewing the table with reference to those who have obtained a place on the list or have been dropped from it, we find that Massachusetts and Connecticut, which already had of all the states the largest percentages of scientific men in their populations—51 and 47 per million—now show the greatest gains. Nearly one fourth of the new men on the list reside in these two states, which have but 5 per cent. of the population of continental United States. At the same time, a comparatively small percentage of their scientific men have failed to maintain their places on the list, so that their net gains have been 22, or about 12 per cent. The figures refer to new men who have obtained places among the thousand in the course of the past seven years or to those who have lost their places on the list, and not to men who have maintained their places and have removed from one state to another. These two states have been fortunate in the possession or skilful in the selection of young men of ability; and credit should be given to their three great educational institutions—Harvard, the Massachusetts Institute and Yale. Another center of scientific activity and growth is found in the states of Illinois and Wisconsin, and is there also due to three leading universities. Illinois has 28 and Wisconsin 13 of the men added, while of those dropped from the list Illinois has 18 and Wisconsin none. The two states have a net gain of 23 men, or about 28 per cent. Missouri also shows a gain, while the other north central states remain about stationary.

New York, New Jersey and Pennsylvania have more men who have died or been crowded off the list of the first thousand scientific men than have attained places on it. The net loss has been 22 in New York, 3 in New Jersey and 12 in Pennsylvania. This is a sinister record for this center of vast wealth with its richly endowed universities. These three states can but ill bear comparison with the two progressive centers in the northeast and north central states.

The District of Columbia has 26 of the men added and 36 of the men dropped out. It has suffered more serious losses from death than any other region. Washington and the scientific bureaus under the government have lost somewhat. Large appropriations are made and useful work is done, but there seems to be a lack of men of genius and a paucity of important discovery. The Smithsonian Institution under Henry, Baird and Langley, the Geological Survey under Powell, the Naval Observatory when Newcomb and Hall were there, had promise and distinction which they lack to-day.

The western states have about maintained their creditable position, while the southern states have fallen still further behind. South Carolina, Georgia, Florida, Mississippi, Alabama, Louisiana, Tennessee and Kentucky had among them only 10 scientific men in the list of 1903. One man has been added and six lost. This record must be characterized as discreditable. The policy which leaves the south almost without scientific leaders is most foolish, even from the strictly utilitarian point of view. It appears that here too "he that hath, to him shall be given: and he that hath not, from him shall be taken even that which he hath."

The institutions with which two or more of the men added to the list are connected, together with those dropped, are given in Table II. As has been already indicated, Harvard, the Massachusetts Institute of Technology and Yale in New England, and Chicago, Illinois and Wisconsin in the north central region have been particularly fortunate in the possession of younger men who have acquired scientific reputation in the course of recent years. The same institutions have been equally happy in not having many men who

TABLE II. INSTITUTIONS WITH WHICH THE MEN ARE CONNECTED WHO HAVE BEEN ADDED AND DROPPED

Institution.	Men Added.			Men Dropped.			
	New.	Old.	Total.	Out.	Dead.	Gone.	Total.
Harvard	22	1	23	6	3	0	9
Chicago	13	1	14	3	1	0	4
Wisconsin	11	1	12	0	0	0	0
Yale	11	1	12	0	4	0	4
Johns Hopkins	9	1	10	5	1	0	6
Illinois	8	2	10	3	1	0	4
Mass. Inst.	8	1	9	2	0	0	2
Carnegie Inst.	8	0	8	1	0	0	1
Columbia	8	0	8	12	3	1	16
Stanford	6	1	7	1	0	0	1
Dept. of Agr.	6	0	6	11	0	0	11
Michigan	5	0	5	0	2	3	5
Cornell	5	0	5	6	1	0	7
Princeton	5	0	5	3	1	0	4
Geol. Survey	4	1	5	3	1	0	4
Bur. of Standards	4	0	4	0	0	0	0
California	4	0	4	4	2	0	6
Missouri	4	0	4	1	0	0	1
Nebraska	4	0	4	2	1	0	3
Bryn Mawr	3	1	4	0	0	1	1
Western Reserve	3	1	4	0	0	0	0
Amer. Museum,	3	0	3	1	0	0	1
N. Y. University	3	0	3	2	0	0	2
Pennsylvania	3	0	3	4	0	0	4
Minnesota	2	1	3	3	0	0	3
Brown	2	0	2	1	1	0	2
P. I. Bur. of Sci.	2	0	2	0	0	0	0
Catholic	2	0	2	1	0	0	1
Cincinnati	2	0	2	2	0	0	2
Goucher	2	0	2	0	0	0	0
Indiana	2	0	2	1	0	0	1
Kansas	2	0	2	0	1	0	1
North Carolina	2	0	2	0	0	0	0
Northwestern	2	0	2	3	1	0	4
Ohio	2	0	2	2	1	0	3
Rockefeller Inst.	2	0	2	0	0	0	0
Smithsonian Inst,	2	0	2	4	5	0	9
Texas	2	0	2	2	0	0	2
Washington (St. Louis)	2	0	2	0	0	0	0
Wellesley	2	0	2	1	0	0	1
Elsewhere	46	18	64	111	28	5	144
Total	238	31	269	201	58	10	269

have lost their positions on the thousand. This double success can not be attributed to chance, but must indicate skill in the selection of men or an environment favorable to good work. The Johns Hopkins and Stanford also stand well. Columbia, Cornell and California are the three universities which have lost the most. While Harvard and Yale have about three times as many men who have won a place as have lost it, Columbia has twice as many who have been dropped from the list as have been added to it. In the other universities and colleges the changes have been smaller, but they have considerable significance and deserve careful consideration. When we remember that seven adjacent states have not a single one of these men within their borders, it is not a small thing for institutions such as the University of North Carolina or Goucher College to have two of them. We may well ask why Pennsylvania should

TABLE III. THE INSTITUTIONS FROM WHICH MEN GRADUATED WHO WERE ADDED TO OR DROPPED FROM THE LIST

	Men Added.			Men Dropped.		
	A.B.	Ph.D.	Total.	A.B.	Ph.D.	Total.
Harvard	20	27	47	17	4	21
Chicago	5	27	32	0	1	1
Yale	15	13	28	5	2	7
Hopkins	5	22	27	2	17	19
Cornell	9	12	21	7	5	12
Columbia	4	14	18	8	8	16
Wisconsin	8	4	12	2	1	3
Michigan	8	2	10	6	0	6
Mass. Inst.	7	2	9	3	0	3
Minnesota	6	2	8	0	0	0
California	5	2	7	2	1	3
Stanford	3	4	7	0	0	0
Brown	5	1	6	2	1	3
Ohio State	6	0	6	0	1	1
Nebraska	5	0	5	3	1	4
Clark	0	4	4	0	2	2
Lehigh	4	0	4	1	0	1
Princeton	3	1	4	4	1	5
Amherst	3	0	3	6	1	7
Indiana	3	0	3	1	0	1
Pennsylvania	1	2	3	3	3	6
Syracuse	2	1	3	3	1	4
Texas	3	0	3	0	0	0
Elsewhere	70	7	77	79	12	91
Total	200	147	347	154	62	216
Leipzig	0	10	10	0	4	4
Göttingen	0	5	5	0	6	6
Berlin	0	3	3	0	3	3
Heidelberg	0	3	3	0	5	5
Edinburgh	2	1	3	1	2	3
Elsewhere	11	6	17	3	11	14
Total	13	28	41	4	31	35
Total	213	175	388	158	93	251
None	19	57	76	42	107	149
Unknown	6	6	12	1	1	2
Grand Total	238	238	476	201	201	402

compare so unfavorably with Yale, or Minnesota with Wisconsin.

Among the non-teaching institutions there is the same direct correlation between the men added and dropped. Institutions which have a good record in one case have it also in the other. It seems almost incredible that it should be possible to measure the efficiency with which an institution is conducted by such simple means, yet the differences can not be attributed to chance. The Carnegie Institution has the largest gains, though in view of its resources and exemption from inherited survivals, it does not compare favorably with some universities. The Bureau of Standards, the Philippine Islands Bureau of Science and the Rockefeller Institute have done well. The Department of Agriculture has lost about twice as many men as it has gained and the Smithsonian Institution with its dependent bureaus about four times as many.

Table III. gives the institutions at which three or more of the 238 scientific men who obtained a place on the list of 1910 received their degrees. The table also gives data for the 201 men who were dropped from the list. Of 232 of the new men whose education is known, all but 19 have the bachelor's degree and all but 57 the doctorate of philosophy or science. Some of those who did not receive the bachelor's degree were educated abroad and have its equivalent, and many of those not holding the doctorate of philosophy are doctors of medicine or have pursued university studies. Among the 1,000 on the list of 1903, 758 are known to have received the bachelor's degree and 544 the doctor's degree. The percentage of those holding the bachelor's degree has increased from 76 to 92, and of those holding the doctor's degree from 54 to 75. Our educational methods are thus becoming more completely standardized or conventionalized. The two men who stood first on the list of 1903, Simon Newcomb and William James, had neither the regular college nor the regular university education. Whether this was favorable or harmful to their genius is unknown; but it is probable that our present educational methods do not favor individuality and its early expression.

Harvard stands very clearly in the lead in its influence. Of the 232 men, 20 have received from it their first degree and 27 the doctorate of philosophy or science. Yale is the only university in the same class with Harvard as regards the bachelor's degree, and Chicago and the Johns Hopkins are the only ones as regards the doctor's degree. It is a curious fact that while Columbia and Yale have conferred in the past thirteen years about the same number of doctorates in the natural and exact sciences (189 and 179, respectively) as have Chicago, the Johns Hopkins and Harvard (245, 220 and 178, respectively), each can claim only about half as many of the new men who have obtained places among the thousand. Pennsylvania has the worst record in this respect, having conferred 133 doctorates and having only two doctors among the men added to the list. The 13 men who received the doctorate of philosophy from universities not given on the table received it from 11 different institutions, and the 81 bachelors not accounted for on the table received their degrees from no fewer than 70 colleges.

The colleges of the state universities have done better than those of the Atlantic seaboard. Thus Michigan and Wisconsin have each produced eight of the bachelors, while Princeton and Amherst have produced three, Dartmouth two and Williams one. In the list of 1903, Princeton and Amherst each had 23 bachelors among 758. The technical schools of the east have been more productive than the colleges; thus the Massachusetts Institute has seven and Lehigh four of the new men. Harvard, Yale and Cornell owe their good record to their scientific and technical courses. It is to be feared that the eastern college with "its frivolous amateurism and futile scholasticism" exerts influences actually prejudicial to the scientific career.

Leipzig, Berlin, Göttingen and Heidelberg are the four German universities which this time as last have conferred the largest number

of degrees. Among 175 of the newer men 21 have received the doctorate of philosophy from these four universities, whereas among 544 in the list of 1903, 112 received it from the same institutions. In about ten years the percentage of foreign degrees has decreased to nearly one half, and it is in course of further reduction. The number of foreign men of science educated abroad and coming to this country has, as shown above, also decreased. In so far as these changes are due to the improvement of our universities and to the increase in the number of native scientific men they are gratifying. None the less there is an aspect of the movement which is unpromising. It is not desirable that we should become more provincial than we are.

The education is known of 200 of the 201 men who dropped from the list. About 25 per cent. of these fall out through the probable error of arrangement, but in general they are those who have failed to maintain their scientific standing in competition with their colleagues. Twenty per cent. of those on the list of 1903 were dropped from it; of those on the list who hold the bachelor's degree 21 per cent. were dropped, and of those who hold the doctor's degree 17 per cent. were dropped. Those holding the doctor's degree thus have a small advantage; but this is only because the younger men are more likely to have the doctor's degree and at the same time more likely to maintain their positions.

Harvard had on the list of 1903, 106 of the bachelors and 57 of the doctors. It has now made a gain of three bachelors and 23 doctors. Chicago has made a notable gain, having added five of its bachelors and 27 of its doctors to the list and having lost but one doctor. Yale also has a good record, having increased its bachelors by 10 and its doctors by 11. The Johns Hopkins had 102 doctors on the previous list, nearly twice as many as Harvard and four times as many as Yale. It has lost 17 and added 22, and is thus still far in advance in the number of leading scientific men for whom it has provided higher education. Cornell has gained two bachelors and seven doctors. Columbia has added four bachelors and has lost twice as many; it has added 14 doctors and has lost eight; thus it has gained but two men on the list. The state universities, especially Wisconsin, have good records. Princeton, Amherst, Syracuse and Pennsylvania have lost more men than they have gained. The German universities have done well, having added more men than they have lost, in spite of the fact that the number of students studying in Germany has so greatly decreased. These figures are in part accidental, but they certainly throw a new light on the standards and efficiency of our universities.

TABLE IV. DISTRIBUTION OF THE MEN ADDED ACCORDING TO THEIR POSITIONS IN THE THOUSAND AND IN RELATION TO THEIR AGES

Science.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	No.	Per Cent.
Math.	0	3	1	1	3	2	3	2	2	4	21	*26.2*
Physics	0	2	1	3	3	7	8	5	8	7	44	*29.3*
Chem.	0	1	1	3	2	5	6	9	8	9	44	*25.1*
Astr.	0	0	0	1	0	1	2	1	0	2	7	*14.0*
Geol.	0	0	0	1	2	3	4	1	4	1	16	*16.0*
Bot.	0	0	3	2	0	2	5	4	6	1	23	*23.0*
Zool.	0	0	2	0	3	1	5	6	4	8	29	*19.3*
Physiol.	0	1	1	0	2	1	2	0	1	7	15	*37.5*
Anat.	0	0	0	1	0	1	0	0	0	4	6	*24.0*
Path.	0	0	1	1	3	3	4	3	2	0	17	*28.3*
Anth.	0	0	0	0	2	0	0	1	1	1	5	*25.0*
Psychol.	0	0	0	1	1	1	1	1	2	4	11	*22.0*
Number	**0**	**7**	**10**	**14**	**21**	**27**	**40**	**33**	**38**	**48**	**238**	*23.8*
25–29	0	0	0	1	1	1	1	1	0	1	6	
30–34	0	4	2	2	5	4	5	6	7	10	45	
35–39	0	1	4	7	10	13	15	11	14	17	92	
40–44	0	2	4	3	3	9	12	9	9	11	62	
45–49	0	0	0	0	1	0	3	3	6	6	19	
50–54	0	0	0	0	0	0	2	0	2	3	7	
Not known	0	0	0	1	1	0	2	3	0	0	7	
Number	**0**	**7**	**10**	**14**	**21**	**27**	**40**	**33**	**38**	**48**	**238**	

Table IV. shows the distribution of the 238 new men among the twelve sciences in relation to their positions in the thousand and the relation of their ages to the positions. The additions to each science are in the neighborhood of 25 per cent. and the departures from this average are within the limits of chance variation, but only 14 per cent. of the astronomers and 16 per cent. of the geol-

ogists are new, while 37.5 per cent. of the physiologists are new. Astronomy and geology are the sciences which were the most forward in the last generation, and this would lead us to expect a smaller number of changes apart from deaths.

None of the new men attains a place in the first hundred, seven reach the second hundred, ten the third and fourteen the fourth. Those who reach the highest positions are in the mathematical and exact sciences; men of exceptional ability advance more rapidly than in the natural and descriptive sciences.[4] Their success probably depends more on innate genius and less on persistent work. There are more "prodigies" in mathematics than in any other science, and they are more likely to maintain their promise. In this and in certain other respects mathematics is related to music and chess.

Nearly all the men obtain recognition between the ages of 30 and 45. They do their work earlier and have their ideas still earlier. Those who do not have their ideas before they are thirty are not likely to have them, and those who do not do good work under forty-five are not likely to do it. Not a single man over fifty-five has attained a place on the list, and only one man over forty-five has attained a place as high as the fifth hundred. The average age of those added to the thousand is 38.1 years and of those dropped from it 53.6 years. The corresponding median ages are 37.9 and 50.9 years. The writer knows a number of men who think that they have been hindered from doing research work by teaching or other distractions and intend to take up such work later, as when they retire on a pension, but they will almost inevitably fail.

While those added to the thousand are comparatively young, there are only six under thirty years of age, and only the same number in the complete list of the thousand leading scientific men. This is significant and disquieting. A man of genius is likely to do his work at an early age and to receive prompt recognition. Kelvin was appointed full professor at Glasgow at 22, Thomson at Cambridge at 26, Rutherford at McGill at 27. Men of science of this age and rank simply do not exist in America at the present time; nor is it likely that we are faring better in scholarship, in literature and in art. It will be shown further on that the increase in the number of scientific men of standing is only about one half so large as the increase in the population of the country.

It is sometimes urged that our men of genius are drawn into medicine, law and business owing to the large financial rewards of these pursuits. Any one acquainted personally with some of those who earn or get the largest money returns will probably doubt whether they are in fact men of genius superior to our scientific men. The hundred physicians who have the largest incomes selected from the hundred thousand physicians of the country, and the hundred multi-millionaires selected from the million men of business, do not obviously surpass in ability or character the hundred leading scientific men selected from five thousand.

It is indeed probable that the conditions existing in this country are paralleled in Great Britain, Germany and France. In no country does there seem to be a group of younger men of genius, ready to fill the places of the great men of the last generation. This holds not only for science but also for other forms of activity. There is no living peer of Lincoln, Bismarck or Cavour. An Academy of Letters is just now being planned in Great Britain, and its proposed membership is trivial compared with what it might have been in the middle of the Victorian era. It may be argued that we suffer from an illusion of perspective, that many a newspaper writer is the equal of the men of letters of the past, that our young doctors of philosophy would discover laws of motion if Newton had not anticipated them. But it would appear to

[4] In the complete list of the thousand the youngest man among the first 20, among the first 50 and among the first 100 is in each case a mathematician.

be a sufficient answer to write the names of Kipling, Barrie, Shaw, Wells and Chesterton besides the names of Carlyle, Ruskin, Mill, Spencer, Tennyson, Browning, George Eliot, Meredith, Dickens and Thackeray, or the names of the leading British, German or French scientific men now active with the corresponding list for forty years ago.

It is doubtless in part a question of relativity. By the nature of things there can only be a limited number of famous men, and it is not fair to compare a period of twenty years with the most productive period of all history. Both physical science and biological science have been rewritten within a generation, and it is possible that our scientific advance is more rapid to-day than it ever was before. None the less it is ominous for the future that there should be only six men of science of standing in the country who are under thirty years of age, and that the number of scientific men of standing should increase more slowly than the population.

There may be a racial senescence such as we seem to find in comparing the peoples of the Mediterranean with the Scandinavians and Sclavs, but it would be contrary to all our biological knowledge to suppose that the human stock could alter in a generation. In this period the number of individuals who have the education opening the gates to a scientific career has at least quadrupled. But eminent men are lacking; and this we must attribute to changes in the social environment rather than to deterioration of the stock.

The progress of science opposes a real barrier to its further advance. This is not because all the great discoveries have been made. The field of science is not a circumscribed territory which can be completely explored, but rather an area which the larger it becomes, the greater is the contact with the unknown and the more numerous and momentous are the problems pressing for solution. But as the known country becomes larger, each explorer has further to go before he reaches the undiscovered regions, and as he travels over the well-mapped land he loses the strength and vigor required for daring exploration. In plain English, the young man who must spend his early manhood in acquiring knowledge has passed the age at which he is most likely to have new ideas. The inherent difficulty we exaggerate by our educational methods. By our requirements for degrees, by our system of examinations, by our insistence on irrelevant information and ridicule of desirable ignorance and promising mistakes, we crowd on fat when the athlete should be relieved of every superfluous ounce. The doctor's thesis is supposed to be the first productive work; it is completed at the average age of twenty-eight years and is likely to be the working over of the old ideas of an old professor. In the meanwhile the creative instinct has atrophied.

Racial senescence, the lack of emotional stimuli and the accumulations of knowledge will probably set limits to the further advance of science. In the presence of racial senescence we should be entirely helpless, but it is possible that there is no such thing. Twenty years ago the Chinese were called a senile race, but such a statement could not be justified to-day. In a way our stock is as young as any, and the germ plasm may increase as much in complexity as it has since the amœba. Still a highly specialized organism is likely to become unplastic and extinct, and apart from physical exhaustion of the stock there is likely to be a social senescence. This is closely related to the lack of emotional stimuli. Great men and great achievements are likely to be associated with national excitement, with wars, revolutions, the rivalry or consolidation of states, the rise of democracy and the like. Such stirring events will probably disappear from the world civilization of the future, and it may be impossible to devise artificial stimuli adequate to arouse men from a safe and stupid existence. But exactly because within a century the great achievements of science may belong to the past, where the great creations in poetry, art and religion may perhaps now only be found, it is our business to do the best we can to assure the race of an adequate endowment policy.

It is probable that we do not attract to the scientific career the best possible men. There is perhaps no harm in our fellowships and underpaid assistantships, though a subsidized theological education seems to have drawn inferior men to the church. Those who carry on investigation for the benefit of society should be paid for their services by society, and the average doctor's thesis is worth at least $500. We must open the scientific career to many in order to catch in our net the few who count. But large prizes are lacking at both the beginning and the end of the scientific career. It is too closely bound up with college teaching and routine administration; its modest preferments are too often purchased by subservience rather than by independence, by neglect of research rather than by devotion to it. Permanent tenure of office so long as no offense is given, small advancements by the favor of a superior, long vacations and retirement on a pension, are not the rewards to attract the best men or to lead men to do their best work.

The apprentice system in which the beginner assists the expert is the best educational method, and if the right spirit exists on both sides it is the method most conducive to fruitful research. But the teaching of large classes of students having no real interest in the subject is not favorable to investigation. It not only takes the time and strength of the teacher, but to lecture continually "als dictirt euch der heilig' Geist" cultivates an attitude of superficial omniscience subversive of both the caution and the daring which should animate the investigator.

Three fourths of our leading scientific men hold teaching positions and earn their livings by teaching. The accomplishment of research work is usually a factor in the original appointment, and to this extent investigation is encouraged in the graduate schools of our universities. But the reward offered—usually an instructorship at about $1,000 a year—is small, and it is not adjusted to discriminate between men of possible genius and the commonplace squatter. The appointment once received, men are likely to advance by a kind of civil service routine, being on the average assistant professors with a salary of $1,800 at the age of 37 and full professors a little later at a little higher salary. The small advances in salary which may thereafter be given have but little connection with successful research. At the age of sixty-five the professor is no longer regarded as worth his salary, and is put aside on a pension at a time of life when men in other callings earn more than ever before. The only reward open to the professor is the presidency or some other executive position which takes him away from research work.

Money is certainly not the main thing in the world, but the desire for money is by no means so materialistic as is commonly assumed. The pursuit of wealth is an idealistic passion; it is rarely for the gratification of sensual pleasures and usually at the sacrifice of these. It is closely associated with the family—the creation of a home, the education of children, their establishment in life, the transmission of family sanctions and traditions. The pursuit of fame or reputation is usually far more selfish. It is further the case that we measure performance in terms of money. In each career those who do the best work are likely to receive the largest money rewards. These are consequently not only desirable as improving the conditions of living and of the family, in giving security for the future and in providing facilities for further work, but they are also ideal symbols of useful service. If the university president receives three times the salary of the professor and the professor's salary depends on the president's favor, the office of the professor is degraded. If the scientific man in the government service receives the salary of a clerk and is subject to the orders of a superior, he will be treated like a clerk and in the end will deserve no better treatment. As the writer has said:[5] "Professors and scholars are not sufficiently free or sufficiently well paid, so there is a

[5] "The Case of Harvard College," *The Popular Science Monthly*, 76: 604–614, June, 1910.

lack of men who deserve to be highly rewarded, and we are in danger of sliding down the lines of a vicious spiral, until we reach the stage where the professor and his scholarship are not respected because they are not respectable."

University professors and scientific men doubtless belong to the privileged classes. If their salaries are too small in comparison with the incomes of the classes, they are ample in comparison with the wages of the masses. But the salaries and rewards are not adjusted to performance. In Germany the docents in the universities have had a meager support, but the professorship has been maintained as a high office. Promotion to it has not as a rule accrued through favor, through length of service, or even through personal presentability or skill in teaching, but as a reward for research work in which a man is judged by his peers. To this method of university administration must in large measure be attributed the primacy of Germany in research during the past century. In Great Britain and in France also the exceptional man has received exceptional honors.

In this democracy we face conditions into which the other nations are likely to follow us. Geheimrats, knights and academicians may become no more reputable than our LL.D's. As scientific men increase in numbers and their work becomes more highly specialized, it becomes more and more difficult to use fame and social distinction as rewards. The most plausible expedient would appear to be the establishment of research positions in our universities, in our endowed institutions and in the government service, better paid and more free than any now existing. By the will of Senator Vilas, the University of Wisconsin will have ten professorships with salaries of $10,000 and freedom from routine teaching. If each large university has such a scheme, the vacancies being filled by the professors and the position and salary being for life, a comparatively small expenditure would go far toward attracting exceptional men to the academic and scientific career and stimulating them to do exceptional work.

The difficulty confronting us is that our competitive system of payment does not apply to services rendered to society. The physician must promote health, the lawyer prevent litigation and the editor conserve decency at their own cost and to their own cost. The scientific man is not directly paid for his research work; he often has difficulty to find a charity that will publish it. The man of letters was formerly dependent on a patron, but thanks to the printing press, the increase of the reading public and the copyright laws, his condition has improved. The patent office has been of assistance to discovery; its scope should be extended to cover, for example, the production of new varieties of plants and animals, and, if possible, the production of new kinds of ideas. But methods should be devised by which scientific work will be rewarded in some direct proportion to its value to society—and this not in the interest of the investigator, but in the interest of society.

At the same time we must remember that human nature is extremely complicated and imperfectly understood. The fine flower of genius may wither in the sunshine more quickly than in the shade. Children are loved and cherished in direct proportion to the sacrifices made for them. There is a subtle distinction between play and work. It might happen that the joy of creation in art and science would be crushed by professionalism. The dominant motives of conduct vary from age to age, from land to land, from group to group, from individual to individual. But in spite of our ignorance of the causes of conduct we may have some confidence that among the restless nations of the west, poverty, celibacy, obedience and obscurity are exotic ideals which can not be used to make the scientific career attractive.

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(*To be concluded*)